INSTRUCTION MANUAL

MODEL 419

AUTOMATIC RANGING PICOAMMETER

KEITHLEY INSTRUMENTS

WARRANTY

We warrant each of our products to be free from defects in material and workmanship. Our obligation under this warranty is to repair or replace any instrument or part thereof which, within a year after shipment, proves defective upon examination. We will pay domestic surface freight costs.

To exercise this warranty, call your local field representative or the Cleveland factory, DDD 216-248-0400. You will be given assistance and shipping instructions.

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To insure prompt repair or recalibration service, please contact your local field representative or the plant directly before returning the instrument.

Estimates for repairs, normal recalibrations, and calibrations traceable to the National Bureau of Standards are available upon request.

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SPECIFICATIONS

RANGE: 10^{-13} ampere full scale to 10^{-2} ampere in twelve decade ranges. Manual meter scale expansion is provided.

ACCURACY:

Output: ±1.5% of full scale from 10^{-2} to 10^{-8} ampere; ±3% of full scale from 10^{-9} to 10^{-13} ampere.

Meter: ±2% of full scale from 10^{-2} to 10^{-8} ampere; ±3.5% of full scale from 10^{-9} to 10^{-13} ampere.

ZERO DRIFT: Less than 1% of full scale per 24 hours with source voltages greater than one volt after a 30-minute warm-up, except the 10^{-13} ampere range where it is 10% per 24 hours.

CURRENT OFFSET: Less than 3×10^{-14} ampere.

INPUT VOLTAGE DROP: Less than 1 millivolt for full-scale meter deflection on all ranges when properly zeroed.

EFFECTIVE INPUT RESISTANCE: 0.1 ohm on 10^{-2} ampere range, increasing to 10,000 megohms on 10^{-13} ampere range in decade steps.

ANALOG OUTPUT:

Output: ±3 volts at up to 1 milliampere for full-scale meter deflection. Output polarity is opposite input polarity. Provision is made for lower voltage outputs.

Resistance: Less than 1 ohm.

Noise: Less than 2% rms of full scale on 10^{-2} to 10^{-12} ampere ranges, less than 5% rms on 10^{-13} ampere range at minimum damping with no external capacitance. Decreases to about 0.3% rms with maximum damping.

RANGE SELECTION AND READOUT: Three modes of range selection are provided: Automatic, Local and Remote. Range is indicated by the illuminated front panel pushbuttons and the Printer Output.

Automatic: Proper range is automatically selected for the applied input current. Range switching time is adjustable in four steps:

1. 133 milliseconds per range from 10^{-9} to 10^{-2} ampere, 267 milliseconds per range from 10^{-13} to 10^{-10} ampere, on 60-cps power lines.
2. Approximately 0.6 second per range.
3. Approximately 1.5 seconds per range.
4. Approximately 4 seconds per range.

Notes: Switching times for range 1 are increased by 20% on 50-cps models. Sampling time before the first range change can increase total time by up to 66 milliseconds.

Most sensitive (resting) range may be preset on front panel from 10^{-13} to 10^{-2} ampere or programmed from the remote control connector as follows:

Range Hold: Closure[1] of contact to ground prevents range change.

Uprange: Closure[1] of contact to ground cycles range to 10^{-2} ampere and holds until contact is released.

Local: Range may be selected by pushbutton on the front panel. A pushbutton switch provides expanded meter deflection for low meter readings.

Remote: Range may be selected from remote locations through a 4-bit binary input. Binary "0" (0000) corresponds to the 10^{-2} ampere range, binary 11 (1101) corresponds to the 10^{-13} range. 1248 code; Closure[2] to ground = 1. Zero check requires a separate input. A switch at the remote location can be used to command remote control or to return control of unit to its front panel setting.

Polarity Selection: Two modes are provided, Local and Remote.

Local: Pushbutton.

Remote: Closure[2] to ground for positive polarity. Open[2] for negative polarity.

Polarity Output: Same line as polarity selection, "—" = > —10 volts @ 1 milliampere, "+" = < —0.5 volt.

Printer Output: 2-line BCD negative and positive outputs permit printout of actual range exponent. Standard Code is 1248. 1224 code may also be ordered.
0 = < ±1 volt 1 = > ±10 volts @ 1 milliampere "0" = 0000.

Inhibit Output: 0 to —0.5 volt except during range changes in automatic mode. > —10 volts at up to 0.3 milliampere during range changing and for one switching time plus about 120 milliseconds after change to permit output to settle.

ZERO CHECK: Allows zeroing without disturbing the input circuit.

REMOTE ZERO CHECK: Closure[2] to ground allows operation of zero check from remote location.

DAMPING: Rise times are much faster than the fastest range-change rates with up to 100 picofarads across the input except on the 10^{-13} ampere range. Rise times may be lengthened with the damping control to about ½ the range switching time selected on 10^{-13} to 10^{-8} ampere range.

CONNECTORS: Input: Teflon-insulated UHF type. Analog Output: Amphenol 80-PC2F. Remote Control: Cannon DA15S. Printer Output: Cannon DA15S. Remote Head: Cannon DA15S.

POWER: 105-125 or 210-250 volts (switch selected), 60 cps, 60 watts.

DIMENSIONS, WEIGHT: 5¼" high x 19" wide x 13½" deep; net weight, 25 pounds.

ACCESSORIES SUPPLIED: Mating input, analog output and printer (or remote) output connectors.

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[1]Closure = < 2 kilohms < ±0.5 volt @ 0.3 milliampere
[2]Closure = < 2 ohms < ±0.5 volt @ 200 milliamperes

[1]Open = > 10 kilohms @ —3.5 volts
[2]Open = > 15 kilohms @ —15 volts

SECTION 1. GENERAL DESCRIPTION

1-1. GENERAL. The Keithley Model 419 Picoammeter automatically measures currents from 10^{-13} ampere full scale to 10^{-2} ampere. It is compatible with digital converters, printers and computers in automated systems. In addition, control lines enable the Model 419 to be remotely programmed for desired range.

1-2. APPLICATIONS. In production testing, the Model 419 can be incorporated into many systems for electronic component evaluation. Uses include measuring leakage currents of semiconductors, insulators and capacitors, and testing characteristics of electron tubes, photo diodes and multipliers. In research, development and nuclear monitoring, the Model 419 can be designed into systems to automatically measure and record current from photo-sensitive devices, electron multiplier tubes and ion collectors. The Picoammeter can also be used with vacuum gauges and chromatographs.

1-3. FEATURES.

a. Rapid Measurement. The Model 419 can provide an accurate reading within 320 milliseconds for a measurement requiring one range change. With six range changes, less than 1 second is required for a complete measurement. Optimum performance for high-speed measurements at various input levels is obtained using front panel Range Rate and Damping controls.

b. Remote Control. Where automatic ranging is not required and particular current ranges are repeatedly used, the Model 419 range, polarity and zero check can be remotely programmed. Control can be accomplished by a variety of devices, from computers to remotely located manual switches.

c. Range Output Information. Permanent records for manual or automated data processing can be made of all readings, including range and polarity. BCD outputs are available for use in recording on printed or magnetic tape, and on punched cards or paper tape. The analog output readily drives a digital converter. The Inhibit Output can be used to prevent recordings during range changes or to indicate when a reading is invalid.

d. Overload Recovery. Other features of the Model 419 include quick recovery from small overloads to maintain speed of range changing. Good stability — less than 1% drift per day — minimizes the need for frequent zeroing. Manual range selection permits convenient system checkout.

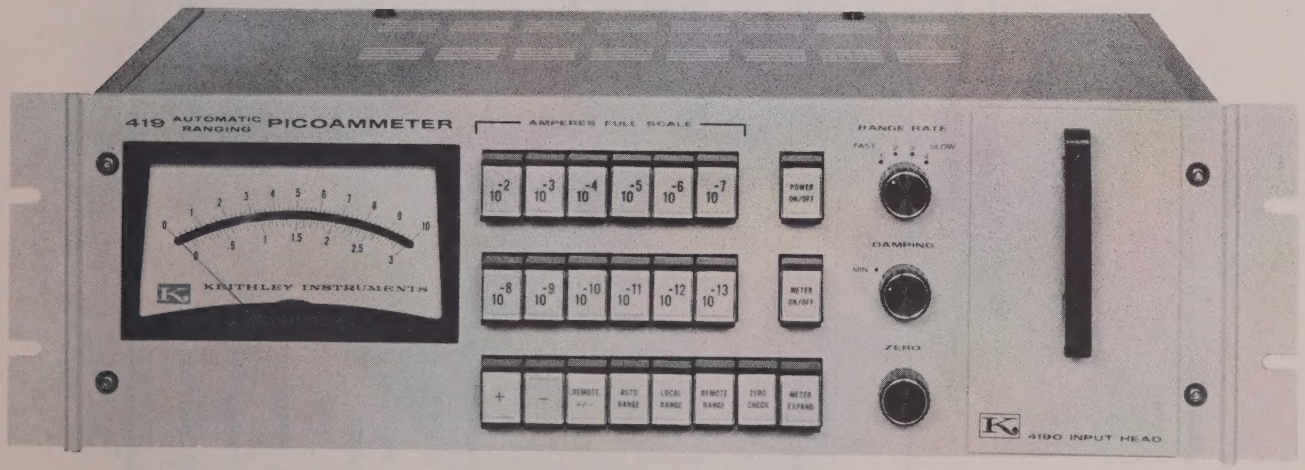


TABLE 1-1.
Front Panel Controls

Control	Function Description	Paragraph
POWER ON/OFF Switch	Power on: Depress to turn on power (and to light button).	2-2
METER ON/OFF Switch	Sets meter circuit: Depress to turn on (and to light button).	-
RANGE RATE Switch	Sets ranging rate in automatic mode.	2-6
DAMPING Control	Sets damping rate.	
ZERO Control	Adjusts for zero offset.	2-4
AMPERES FULL SCALE (12) 10^{-2}A to 10^{-13}A	Sets full scale current sensitivity in LOCAL RANGE mode.	2-3b
Polarity Pushbuttons (3) +, -, REMOTE	Sets polarity of meter.	-
Range Mode Pushbuttons (3)		
AUTO RANGE	Sets automatic ranging mode.	2-3a
LOCAL RANGE	Sets manual ranging mode.	2-3b
REMOTE RANGE	Sets remote ranging mode.	2-3c
ZERO CHECK Pushbutton	Connects input for zero adjustment.	2-4
METER EXPAND Pushbutton	Expands meter scale to 0-3 full scale.	

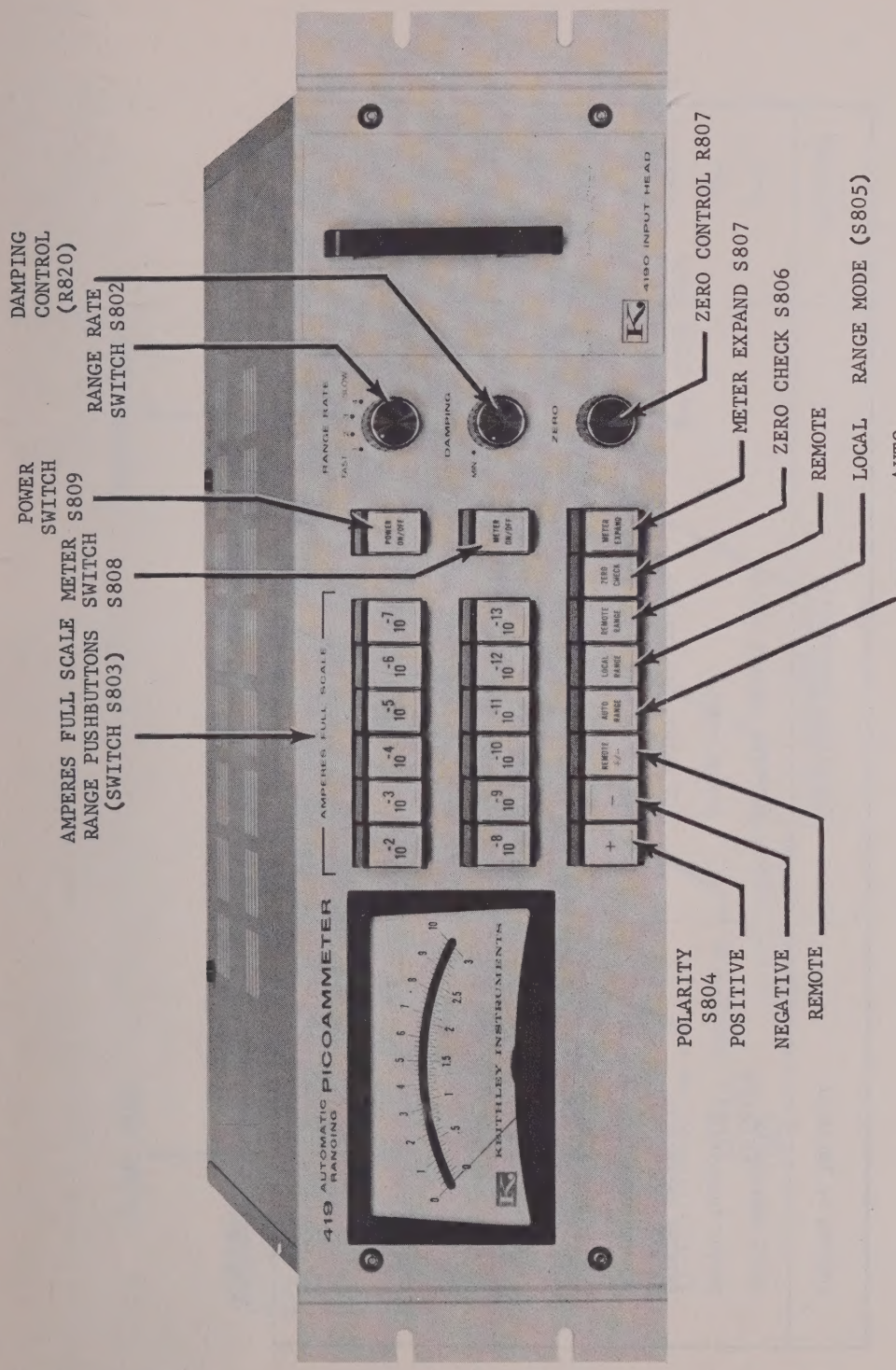


FIGURE 2. Front Panel Controls.

TABLE 1-2.
Rear Panel Controls and Terminals

Control or Terminal	Functional Description	Paragraph
INPUT Receptacle	UHF-type coaxial input.	2-5
OUTPUT Receptacle	Analog output.	2-9
PRINTER Receptacle	BCD output information.	2-9
REMOTE CONTROL Receptacle	Remote control input lines.	2-10
REMOTE HEAD Receptacle	Remote Head auxiliary connections.	2-5
Fuse	Type 3AG slow-blow 117V: 0.75A 234V: 0.375A	-
Line Switch	Sets instrument for either 117 or 234V.	2-2
SPARE Receptacle hole	Provides auxiliary connection to spare. 15-pin connector.	-

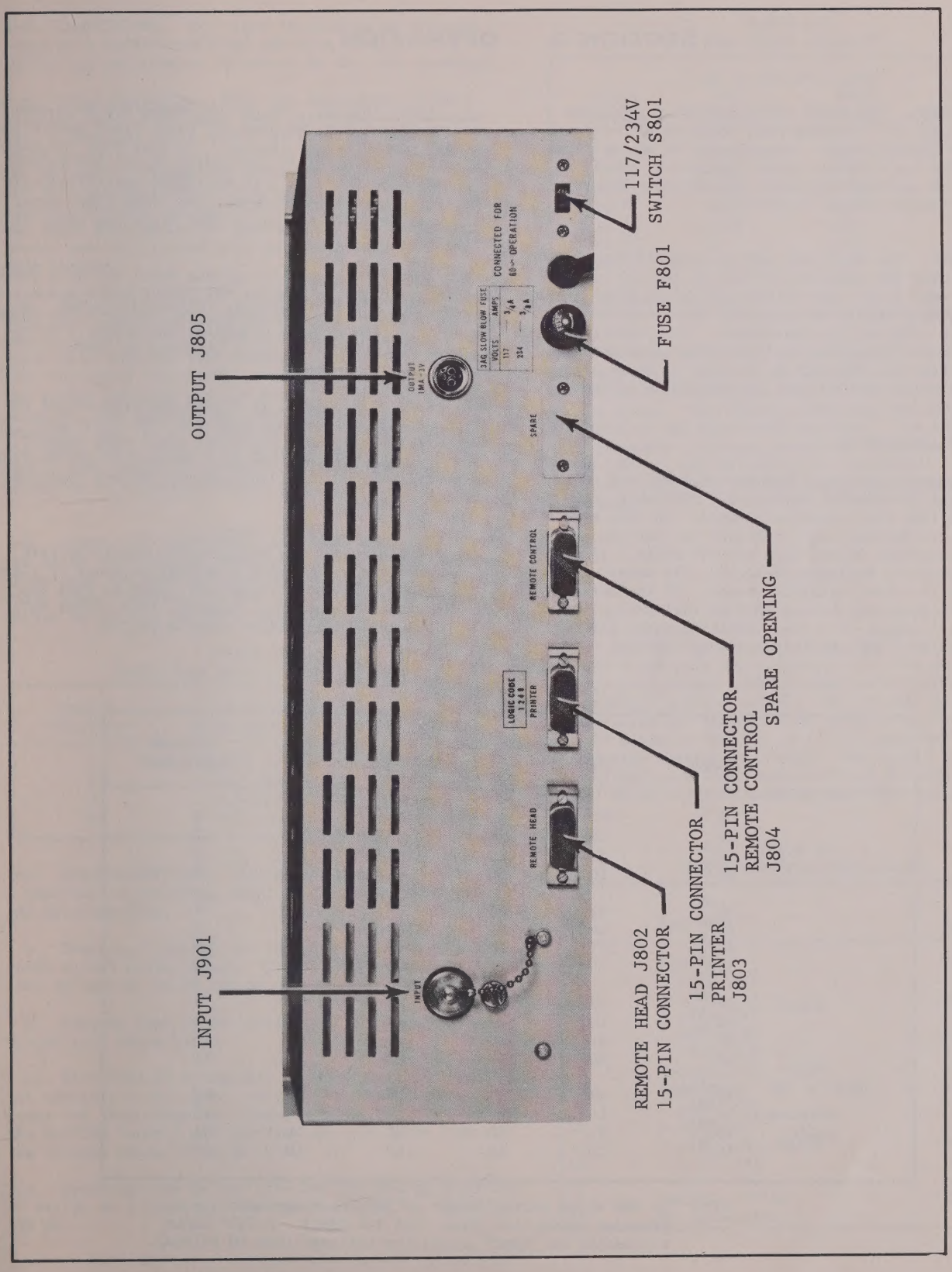


FIGURE 3. Rear Panel.

SECTION 2. OPERATION

2-1. GENERAL. The Model 419 Picoammeter indicates current from 10^{-13} amperes full scale to 10^{-2} amperes in twelve decade ranges. Ranging may be accomplished through the use of three modes; Automatic, Local, or Remote. In addition the Model 419 provides BCD outputs and remote control flexibility.

2-2. POWER. The Model 419 may be operated from line voltages over the range of 105-125 or 210-250 volts. (Set the rear panel line switch for 117 or 234V). The line frequency should be specified for either 50 or 60 Hz when ordering the instrument. (To convert to 50 Hz from 60 Hz replace resistor R701 on PC-168 with Keithley Part No. R94-402K.) To turn on power depress the POWER pushbutton so that the button is lighted.

2-3. OPERATING MODES.

a. Automatic Ranging. To use the Model 419 as an autoranging picoammeter depress the AUTORANGE pushbutton so that the button is lighted. In this mode the range is automatically selected so that the meter indicates between 8% and 100% of full scale. If the meter indication decreases below 8%, the meter will downrange to a more sensitive range. If the meter indication increases beyond 100% of full scale, the meter will uprange to a less sensitive range (10^{-4} amperes to 10^{-3} amperes for example).

b. Local Ranging. To use the Model 419 as a manual ranging picoammeter depress the LOCAL RANGE pushbutton so that the button is lighted. In this mode the range is selected by manually depressing one of the AMPERES FULL SCALE pushbuttons. If the input current exceeds the full scale range selected, the front panel meter will "peg" off scale until a less sensitive range is selected.

c. Remote Ranging. To use the Model 419 as a remote ranging picoammeter depress the REMOTE RANGE pushbutton so that the button is lighted. In this mode the range is selected remotely by grounding the proper combination of remote control lines as shown in Table 2-1.

2-4. ZERO ADJUSTMENT. To adjust for zero offset on the Model 419 depress and hold the ZERO CHECK pushbutton while adjusting the front panel ZERO control. (The ZERO CHECK pushbutton must be held in the depressed position since it will return to the off position automatically.)

NOTE

The instrument may drift beyond specified rate immediately following a mechanical shock or electrical overload or transient (such as when connecting line power). However, this effect will diminish after a short warm-up period.

TABLE 2-1.
Remote Ranging Logic

	Range	Remote Control Terminal #2	#3	#4	#5	Decimal Equivalent
	10^{-2}	HI	HI	HI	HI	0
	10^{-3}	LO	HI	HI	HI	1
	10^{-4}	HI	LO	HI	HI	2
	10^{-5}	LO	LO	HI	HI	3
	10^{-6}	HI	HI	LO	HI	4
	10^{-7}	LO	HI	LO	HI	5
	10^{-8}	HI	LO	LO	HI	6
	10^{-9}	LO	LO	LO	HI	7
	10^{-10}	HI	HI	HI	LO	8
	10^{-11}	LO	HI	HI	LO	9
	10^{-12}	HI	LO	HI	LO	10
	10^{-13}	LO	LO	HI	LO	11
	10^{-10}	HI	HI	LO	LO	12
Alternate	10^{-11}	LO	HI	LO	LO	13
Logic	10^{-12}	HI	LO	LO	LO	14
	10^{-13}	LO	LO	LO	LO	15

NOTE: In the above control logic a "LO" input represents a grounded connection (less than 2.5 ohms). A "HI" input represents an "open" connection (greater than 10 kilohm).

2-5. CONNECTIONS. The input receptacle on the rear panel is a Teflon-insulated UHF-type connector. A shield cap is provided (attached to the main chassis).

a. Local Operation. When the instrument is used with the Model 4190 Input Head installed in the chassis, a shielded cable should be used. A Keithley CS-49 connector is supplied with the instrument for the purpose of assembling a custom length cable (Keithley SC-9 shielded cable is recommended). Since cable capacity affects the response speed of the Model 419 the Input Head should be used remotely if the signal source must be located more than five feet from the main chassis.

b. Remote Operation. To use the Model 4190 Input Head at a remote location an accessory Model 4183 Remote Amplifier cable should be used. To remove the Input Head from the main chassis, remove the cap from the rear panel receptacle, unscrew the captive retaining screw, and pull out the Head from the front of the chassis. For convenience when using the Model 4190 remotely, use the accessory Model 4172 Remote Housing. The Model 4183 cable is offered in standard 10 foot and 25 foot lengths, although longer lengths may be purchased on a special order.

2-6. RANGE RATE SELECTION. The RANGE RATE Switch sets the delay time between range changes. The approximate delay time for each setting is given in Table 2-2. The delay times indicated do not include the total time to settle on a final on-scale indication.

TABLE 2-2.
Delay Time Between Range Changes

Switch Position	Delay Time 50 Hz Operation	60 Hz Operation
1	160 to 320 mS	133 to 267 mS
2	0.7 secs	0.6 secs
3	1.8 secs	1.5 secs
4	4.8 secs	4 secs

2-7. MEASUREMENT TIME. The total measurement time is a function of Overrange time, Ranging time, Rise time, and Settling time.

a. Overrange Time is the time for the amplifier to reach a full scale output. For 60 Hz operation this time is approx. 66 mS (80 mS for 50 Hz operation).

b. Ranging Time is the total time to range to the proper full scale range.

c. Rise Time is a function of input capacity and input resistance on a given range. The typical rise times for each range are given in Table 2-3. Use of the DAMPING control can increase the rise time from the minimum shown in Table 2-3.

d. Settling Time is the time for the analog amplifier to settle on a reading. The settling time is typically 120 mS.

TABLE 2-3.
Rise Times (Typical)

Range Amperes	10 to 90% Rise Time* 50pF Input C	500pF Input C	Input Resistance
10^{-2} to 10^{-7}	0.002	0.002	10^{-1} to $10^{4}\Omega$
10^{-8}	0.01	0.01	$10^{5}\Omega$
10^{-9}	0.01	0.01	$10^{6}\Omega$
10^{-10}	0.01	0.15	$10^{7}\Omega$
10^{-11}	0.02	0.5	$10^{8}\Omega$
10^{-12}	0.1	0.5	$10^{9}\Omega$
10^{-13}	1.0	4.0	$10^{10}\Omega$

*Minimum Damping

2-8. DAMPING ADJUSTMENT. The DAMPING control provides the capability to increase the picoammeter rise time and effectively damp out noise which may be present at the input. The amount of damping available is a function of the RANGE RATE position. The DAMPING control provides a maximum amount of filtering when the RANGE RATE is set to position 4 (maximum). At the minimum RANGE RATE the damping circuit action is at a minimum.

2-9. PRINTER OUTPUT. The Model 419 provides 14 outputs for use with digital printers. The outputs are coded using binary coded decimal information (1-2-4-8 or optional 1-2-2-4 codes). The Printer Output pin connections are specified in Table 2-4. The output "high" state is defined as a level between 10 and 13 volts with respect to common. The output "low" state is defined as a level between 1 and 0 volts. In the "low" state the sink current must not exceed 2 milliamperes.

TABLE 2-4.
Printer Output Connections

Pin No.	Function	Level
1	Common	0V
2	1 x 2^0 (1)	HIGH = -10V
3	1 x 2^1 (2)	HIGH = -10V
4	1 x 2^2 (4) RANGE	HIGH = -10V
5	1 x 2^3 (8)	HIGH = -10V
6	(10)	HIGH = -10V
7	Polarity (- = HIGH)	HIGH = -10V
8	Zero Check (OFF = HIGH)	HIGH = -10V
9	1 x 2^0 (1)	HIGH = +10V
10	1 x 2^1 (2)	HIGH = +10V
11	1 x 2^2 (4) RANGE	HIGH = +10V
12	1 x 2^3 (8)	HIGH = +10V
13	- (10)	HIGH = +10V
14	Inhibit = HIGH	HIGH = -10V
15	No connection	-

a. Range Outputs. Two sets of range outputs are provided; +1, +2, +4, +8, and +10 for positive logic; -1, -2, -4, -8, and -10 for negative logic. The conversion between range and BCD outputs is given in Table 2-5.

TABLE 2-5.
Range and BCD Output Conversion

Range	BCD Output 1	2	4	8	10
10^{-2}A	LO	HI	LO	LO	LO
10^{-3}A	HI	HI	LO	LO	LO
10^{-4}A	LO	LO	HI	LO	LO
10^{-5}A	HI	LO	HI	LO	LO
10^{-6}A	LO	HI	HI	LO	LO
10^{-7}A	HI	HI	HI	LO	LO
10^{-8}A	LO	LO	LO	HI	LO
10^{-9}A	HI	LO	LO	HI	LO
10^{-10}A	LO	LO	LO	LO	HI
10^{-11}A	HI	LO	LO	LO	HI
10^{-12}A	LO	HI	LO	LO	HI
10^{-13}A	HI	HI	LO	LO	HI

b. Polarity Output. This output can be used to indicate the polarity of the input current. The output logic "high" state is defined as a level between 10 and 13 volts with respect to common. The "high" output is negative. If positive logic is required, an inverter circuit should be used as shown in Figure 5.

c. Zero Check Output. This output can be used to indicate the zero check mode. The output logic "high" state is defined as a level between 10 and 13 volts with respect to common. The "high" output is negative. If positive logic is required, an inverter circuit should be used.

d. Inhibit Output. This output can be used to indicate the time interval during which the Model 419 is changing range. The output logic "high" state is defined as a level between 10 and 13 volts with respect to common. The "high" output is negative. If positive logic is required, an inverter circuit should be used. The inhibit output will be "high" for a time interval consisting of the ranging time plus the settling time (120 milliseconds).

2-10. REMOTE RANGE SELECTION. The Model 419 provides remote control lines which may be used to select range, polarity, or zero check mode. The pin connections for remote ranging are given in Table 2-6.

a. Selecting Remote Mode. To select the remote mode depress the front panel REMOTE RANGE pushbutton or connect the Remote Range terminal (Pin 6) to common through a saturated pnp transistor or mechanical switch or relay. When the Remote Range terminal is connected to common, the front panel REMOTE RANGE pushbutton will be illuminated to indicate the remote range condition. Release of the Remote Range terminal will return the instrument to Local or Autorange mode unless the REMOTE RANGE pushbutton is depressed. The switching of the Remote Range control lines should be performed using "break-before-make" contacts to allow for delay times in the control line switching.

b. Polarity Control. To select the polarity by remote control the REMOTE +/- pushbutton should be depressed. A positive polarity is selected by connecting the Polarity terminal (Pin 7) to common through a saturated pnp transistor or mechanical switch or relay. When the Polarity terminal is connected to common the front panel "+" pushbutton will be illuminated. When the front panel meter is not used the METER ON/OFF pushbutton should be turned off. The analog output polarity is always opposite the input current polarity. Thus, the polarity control line may be disconnected since it is not needed when the front panel meter is not used.

c. Range Hold Control. When the Range Hold terminal (pin 13) is connected to common the Model 419 will be held on the range (at that instant) and automatic range changing will be prohibited.

d. Zero Check Control. When the Zero Check terminal (pin 8) is connected to common the Model 419 will be placed in the Zero Check mode.

e. 10^{-2}A Range Control. When the 10^{-2}A control terminal (pin 14) is connected to common the Model 419 will automatically uprange to the 10^{-2}A range and hold. This control line will function only when in the automatic ranging mode.

f. Power Supply Voltages. The +15V and -15V lines (pins 11 and 12) can be used for auxiliary power up to 50 milliamperes each.

TABLE 2-6.
Remote Control Connections

Pin No.	Designation	Function
1	Common	0V
2	Remote (1)	Closure to common selects any range in accordance with Table 2-5
3	Remote (2)	
4	Remote (4)	
5	Remote (8)	
6	Remote Range	Selects Remote Mode
7	Polarity	Selects Positive Polarity
8	Zero Check	Selects Zero Check Mode
9	Ground	Analog ground
10	Output	Analog output
11	+15V Power	Auxiliary Power
12	-15V Power	Auxiliary Power
13	Hold	Selects Range Hold
14	10^{-2}A UpRange	Selects 10^{-2}A Range
15	-	No connection

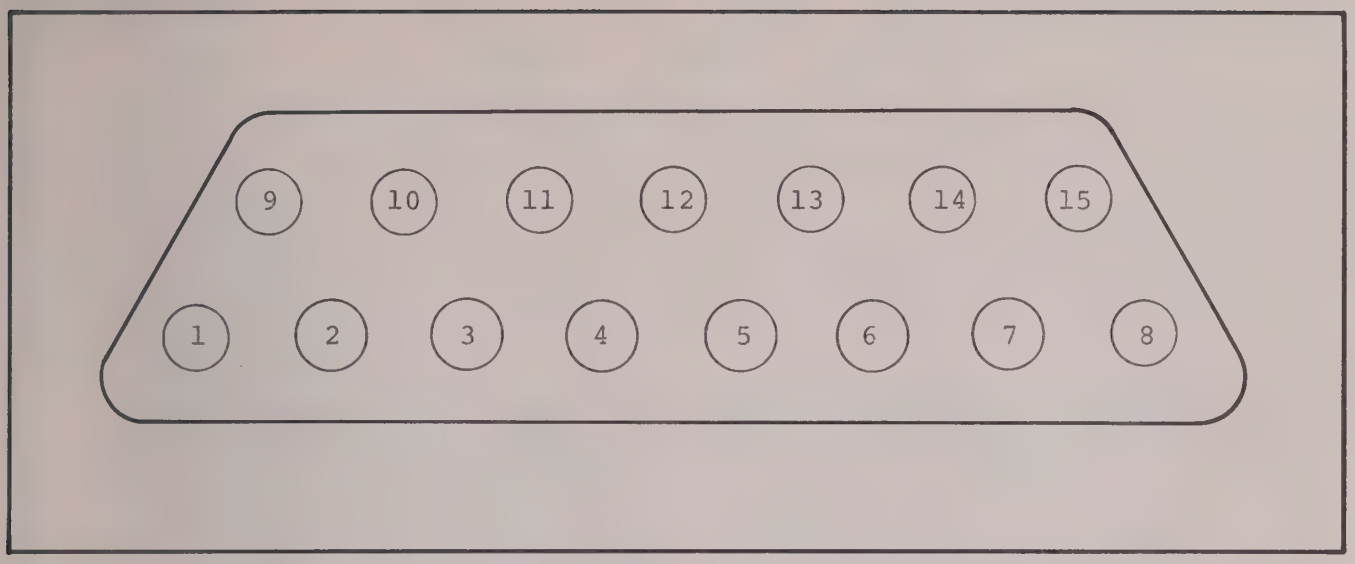


FIGURE 4. Printer Output or Control Connector.

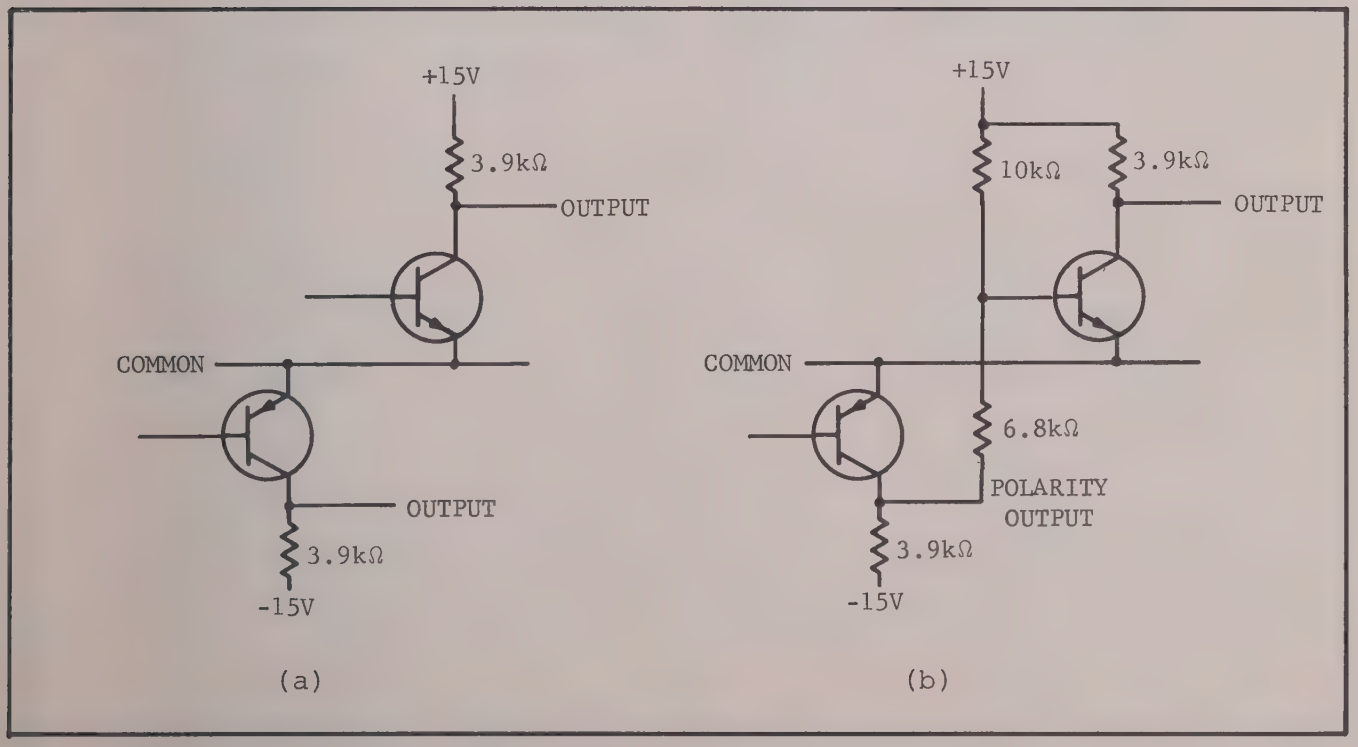


FIGURE 5. Typical BCD Output. (a) Positive and negative logic
(b) Inverter for Polarity Output

SECTION 3. CIRCUIT DESCRIPTION

3-1. GENERAL. The Model 419 picoammeter has been designed to function in two sections; an Input Picoammeter and a main chassis.

a. Model 4190 Input Head. The Input Head contains the picoammeter and range relays. The picoammeter contains a high-gain dc amplifier, range decoding circuit, range resistors, and range relays.

b. Main Chassis. The main chassis contains the power supplies, timing circuits, integrating amplifier, level sensing circuits, electronic counter, delay circuits, binary-to-decimal converter, remote range control circuits and meter circuit.

3-2. INPUT AMPLIFIER. The amplifier is composed of an input stage (electrometer tube V901), an emitter-follower transistor (Q901), a differential transistor pair (Q902, Q903), and an emitter-follower output (Q906). The input signal is applied to the grid of the electrometer tube, V901, through an overload network consisting of capacitors C917 and C918, and resistors R945 and R922 and diodes D901 and D902. Plate voltage for the electrometer tube is supplied through resistor R927; the filament current of 10 milliamperes is obtained from the +15 volt power supply through resistors R925 and R926. Adjusting Coarse Zero Potentiometer, R930, and ZERO CONTROL, R807, (main chassis schematic 21789E) zeroes the instrument by changing the screen voltage. The electrometer tube, V901, is directly coupled to the emitter follower, transistor Q901. When the AMPERES, FULL SCALE Range Selector, S803, is in the 10^{-2} to 10^{-4} positions, resistor R924 and capacitor C919 prevent oscillations. The output of Q901 is directly coupled to Q902. Identical transistors Q903 and Q904 provide temperature compensation for the two amplifier stages. The factor-selected resistor, R933, adjusts the first stage amplifier gain by varying emitter degeneration. The collector of Q902 is directly coupled to the base of the second stage amplifier, transistor Q905. Emitter bias stabilization is accomplished using the zener diode, D903. When the AMPERES, FULL SCALE Range Selector is in one of the 10^{-8} to 10^{-12} positions, an RC network — capacitor C920 and resistor R934 — between the base and the collector of Q905 prevents oscillations. The output of transistor Q905 is directly coupled to the base of the emitter follower output stage using a power-type transistor, Q906. The amplified signal is applied through resistors R716, R717 and R718 (schematic diagram 21788D) to the meter, M801 (schematic diagram 21789E), and the recorder output terminals, J805. The collector of Q906 and the collector resistor, R940, of the second stage amplifier are returned to the -15 volt supply to permit positive and negative outputs. Diodes D904, D905 and D922 and resistor R942 prevent overloading of the output stage.

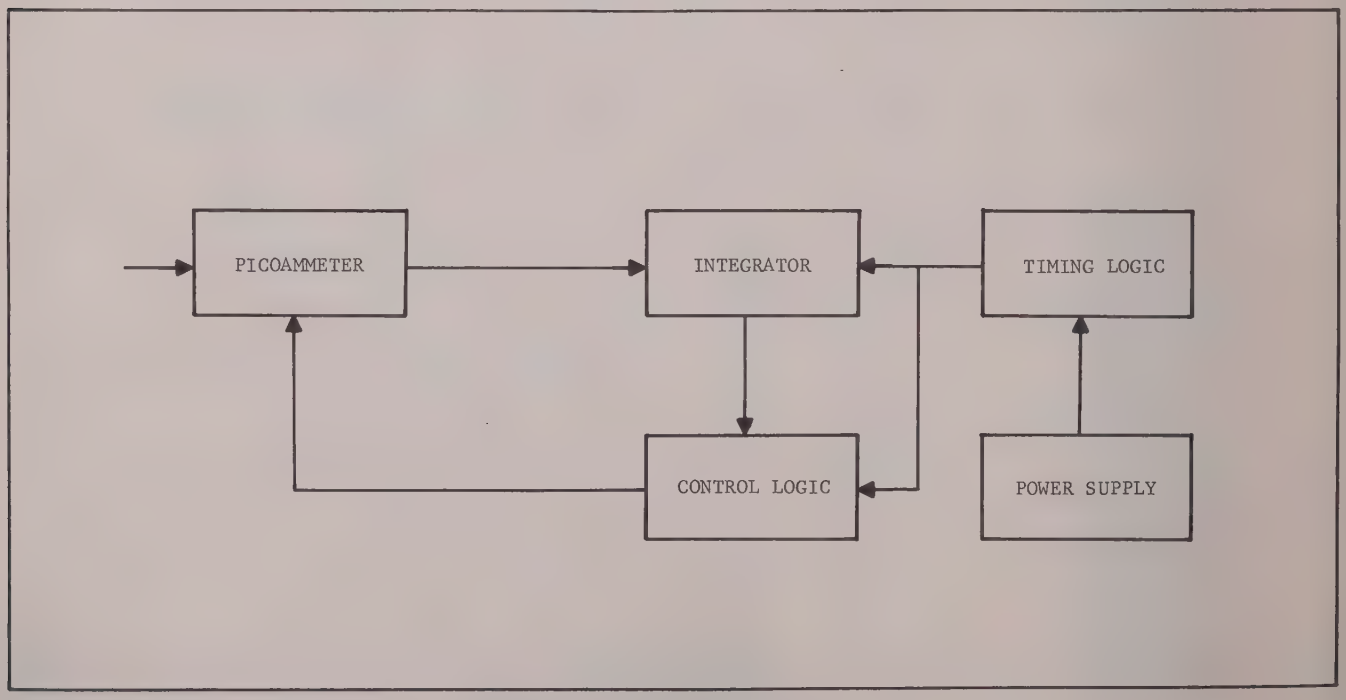


FIGURE 6. Overall Block Diagram.

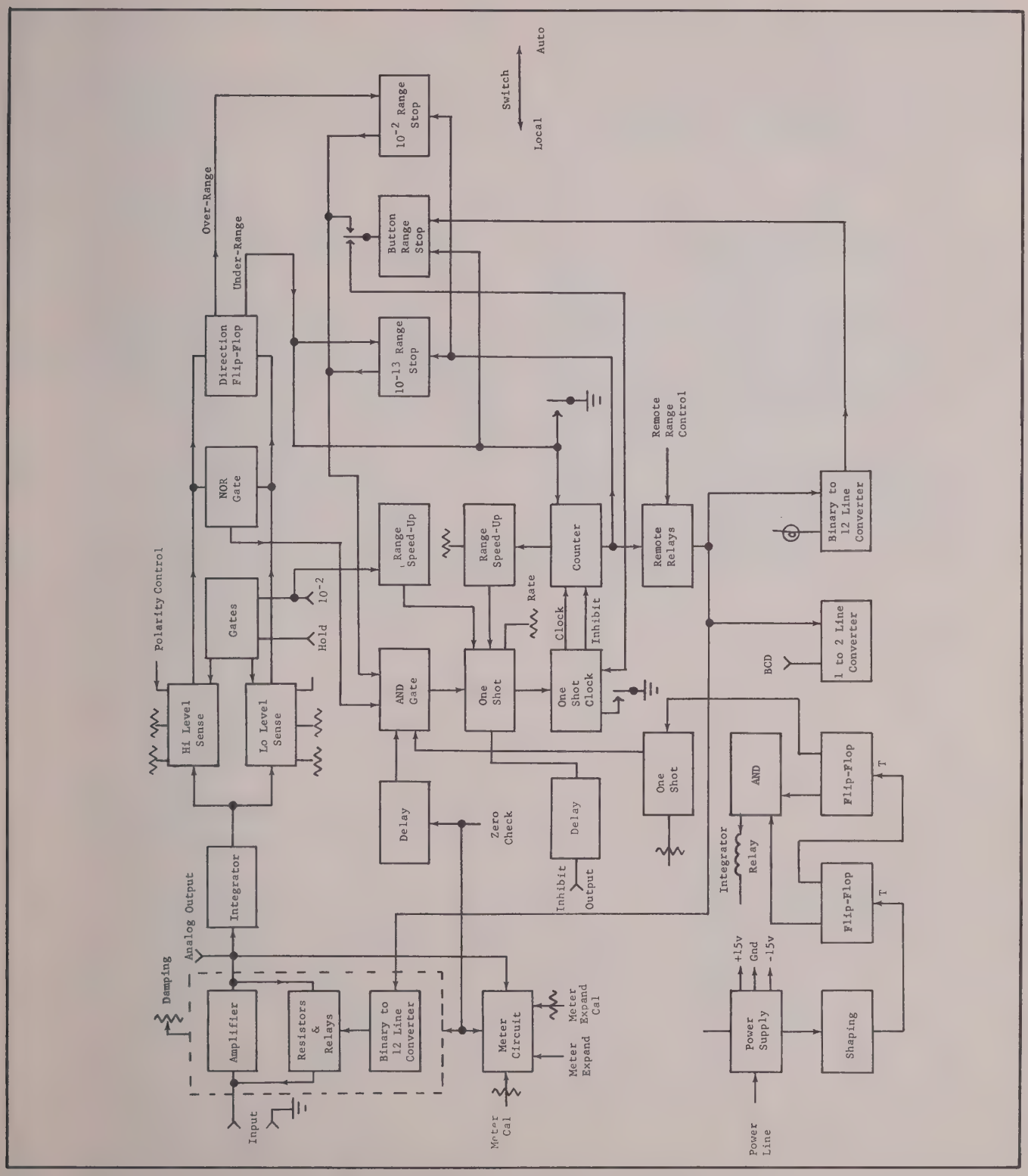


FIGURE 7. Detailed Block Diagram

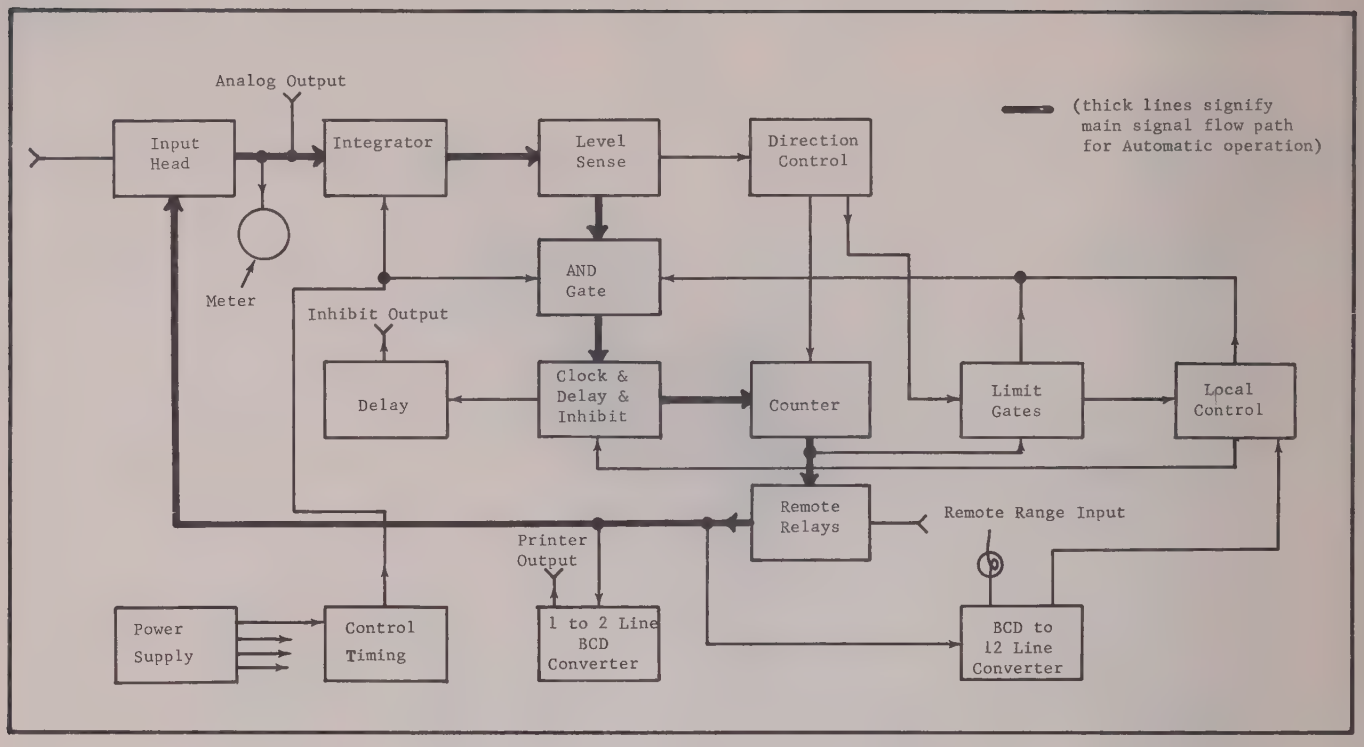


FIGURE 8. Signal Flow Path.

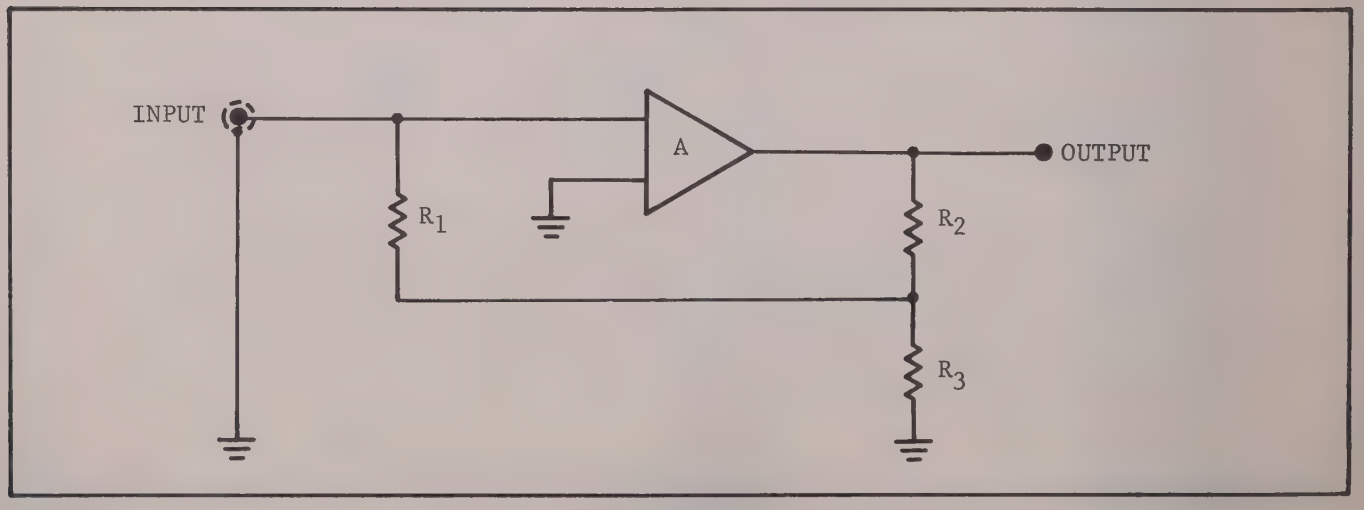


FIGURE 9. Feedback Amplifier.

3-3. FEEDBACK NETWORK. The amplifier output is divided by resistors R912, R914, R915, R946 and is fed back to the amplifier input through one of the range resistors, R902 to R918, selected by positioning the AMPERES, FULL SCALE Range Selector, S803. The feedback resistance on the 10^{-2}, 10^{-3} and 10^{-4} ampere ranges is composed of a parallel combination of resistors. For the 10^{-2} range the resistors composing the feedback combination are R919 through R921. On the 10^{-3} range they are R920 and R921. The 10^{-4} range uses resistors R918 and R921. The 10^{-5} through 10^{-13} ampere ranges employ divider networks. The 10^{-5} through the 10^{-12} range uses resistors R912 and R915 for dividers, while the 10^{-13} range uses R912, R914 and R915.

3-4. DAMPING CIRCUIT. The damping circuit is shown in Figure 10. The time constant T is determined by the following equation

$$T = R_1 \frac{C_1}{1+k} + C_2 \qquad \text{equation 1}$$

where C_1 is the input capacity in farads;
R_1 is the feedback resistance in ohms;
C_2 is the capacity in farads across the feedback resistor;
k is the open-loop gain of the amplifier.

Since the gain of the amplifier is greater than 5,000, the effect of the input capacity on the time constant is very small, except at very low currents, and the time constant is determined primarily by the product R_1C_2. With a 10^{12} ohm resistor, which is used on the most sensitive range, this product can amount to 10 seconds. To decrease the effect of R_1C_2, resistor R_4 and capacitor C_4 are added to the circuit. If $R_4C_4 = R_1C_2$, a lead network cancels a lag network and equation 1 becomes:

$$T = R_1 \frac{(C_1 + C_2)}{1 + k} \qquad \text{equation 2}$$

where both capacities are degenerated by open loop gain. With this arrangement, the circuit is critically damped. The addition of more input capacity will affect the time constant. However, critical damping will not be affected, since basically the circuit is a single time-constant feedback system. The DAMPING Control, R820 (on the Model 419 main chassis front panel) is in the circuit on the 10^{-4} to 10^{-13} AMPERES, FULL SCALE Ranges. Resistor R_5 limits the damping which may be applied depending on the ranging rate being used. In any mode of operation (Local, Automatic or Remote), the slower the range rate the greater the amount of damping that may be applied. Therefore, to obtain maximum damping the RANGE RATE Switch on the main chassis front panel must be in position #4. To zero check the Picoammeter, the output is connected directly to the input (K901). Also, the frequency response of the amplifier must be changed to prevent oscillation (K902).

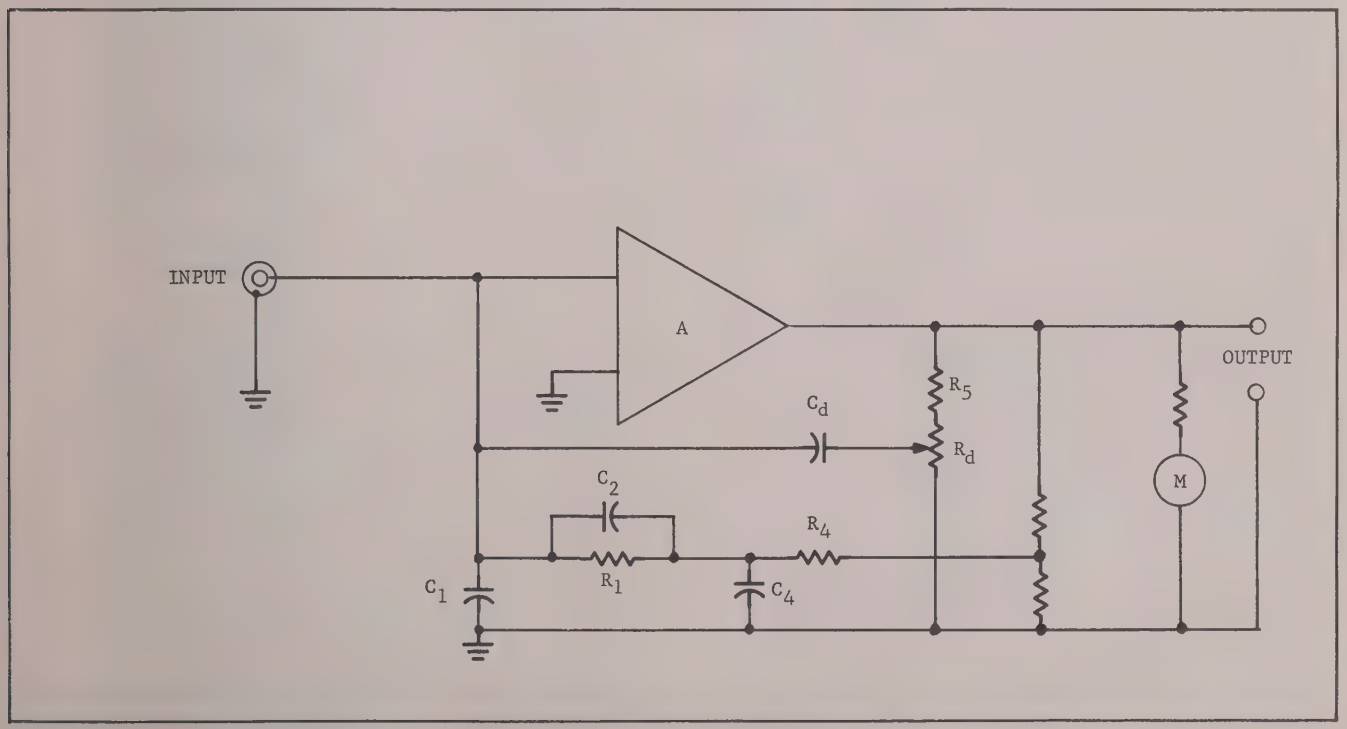


FIGURE 10. Feedback Network.

3-5. TIMING SIGNALS (Printed Circuit Boards PC-161, PC-162, PC-163, PC-168 and Schematic Diagrams 21782D, 21783D, 21784E, 21788D). When the Model 419 is in the Automatic Ranging Mode, the system is operated by timing signals derived from the line frequency. Capacitor C104 couples the sine wave line frequency into a shaping circuit composed of transistors Q201 and Q202. This 60 cycle (50 cycle) square wave frequency is then divided by two flip-flop stages, transistors Q203 and Q204, and Q205 and Q206. The output of these stages are then combined in an AND gate, transistor Q207, to form a drive signal for integrator relay, K701. The output of the second flip-flop stage, transistors Q205 and Q206, is differentiated and applied to a mono-stable transistor stage, Q308, Q309 and Q313. The output of this mono-stable stage is differentiated and used as a Read Signal to determine when the output of the integrator is to be analyzed. An adjustable delay, potentiometer R345, compensates for the time lag between removal of the coil voltage and the contact opening of integrator relay K701.

3-6. INTEGRATOR (Printed Circuit Board PC-168 and Schematic Diagram 21788D). An integrating amplifier, (transistors Q703 through Q710) with integrating capacitor C702 and relay K701 is used as a buffer between the picoammeter and the analogue level sensors. This integrating amplifier removes all line frequency noise (and multiples of line frequency noise) picked up by poorly shielded current sources. With the integrator relay closed (coil energized), the output of the integrator is equal to the zero offset of the field effect transistors, Q703 and Q704. When the relay contacts open, the integration period starts. The integration period ends when the integrator output is analyzed by the Read Signal. The exact time between the contact opening and the Read Signal must be a submultiple of the line frequency (66.67 milliseconds for 60 Hz units and 80 milliseconds for 50 Hz units) to assure complete rejection of all line frequency noise components. Resistor R_i and Capacitor C_i (Figure 17) are selected such that the time constant of their produce ($R_i \times C_i$) is equal to the integration period, so that the integrator has a dc gain of -1. For example, if e_{in} is equal to +1 volt dc, e_o will equal -1 volt at the end of the integration period. Any inaccuracy caused by C_i, R_i or the unbalanced input FETs is compensated in the adjustment of the level sensors which follow the integrator.

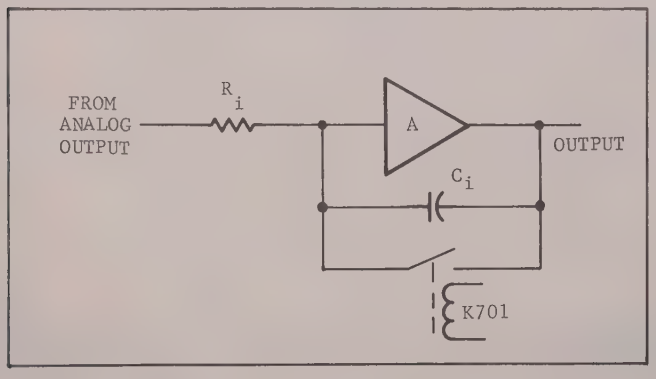


FIGURE 11. Integrator Circuit.

3-7. LEVEL SENSORS (Printed Circuit Board PC-167 and Schematic Diagram 21787E). Two analogue level sensors are connected to the integrator outputs. One determines overrange and one determines underrange. An overrange state exists when the absolute value of the output, e_o, is greater than 3 volts. An underrange state exists when the absolute value of the output, e_o, is less than 0.24 volt (See Figure 18). These level sensors are high gain differential amplifiers. The overrange sensor is composed of transistors Q601 through Q606. The underrange sensor is composed of transistors Q609 through Q612, Q619 and Q620. Connected to the output of the analogue level sensors are solid-state dpdt switches composed of transistors Q615, Q616, Q617, Q621, Q622, Q624 and Q625. Relay K601 and the solid-state switches are controlled by the polarity buttons, S804. Tables 3-1 and 3-2 and Figure 11 explain level sensor operation and phasing of relay K601 and the solid-state switches. The outputs of the level sensors are connected to a NOR gate, transistor Q401, and to the direction flip-flop, transistors Q408 and Q409 (Printed Circuit Board PC-165 and Schematic Diagram 21785E). Table 3-2 gives the logic operation of these items. When either level sensor is tripped, generating a range change condition, the NOR gate gives an output and the direction flip-flop shows the direction of range change necessary. The level sensors are connected to the integrator output which starts at zero output at the beginning of each integration cycle and goes to final value at the time of the Read Signal. Therefore, the range change signal and direction control must be analyzed at the Read Signal. In automatic operation two control lines are available: range-hold and up-range (go to 10^{-2} ampere and hold until released). The range-hold line operates on the solid-state switches of the level sensors to prevent any up-range or down-range signal from appearing. The up-range line operates on the solid-state switches to make an up-range condition appear at the level sensor outputs. Also, the range settling delay is reduced by transistor Q608 to allow the Model 419 to get to the 10^{-2} ampere range quickly.

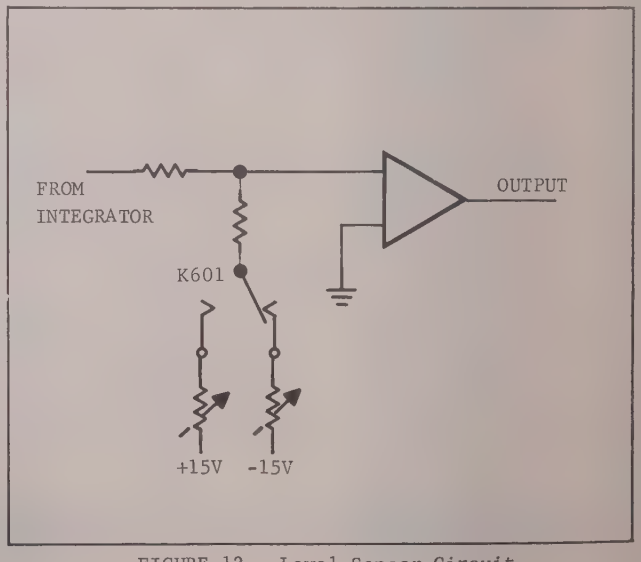


FIGURE 12. Level Sensor Circuit.

TABLE 3-1.
Level Sensor Circuit

Polarity Setting	Input Level	Overrange Output	Underrange Output
+	greater than +3V	-15V	-
+	between +0.24V and +3V	0	0
+	between 0 and +0.24V	-	-15V
-	between -0.24V and 0V	-	-15V
-	between -3V and -0.24V	0	0
-	less than -3V	-15V	-

TABLE 3-2.
Level Sensor Logic

Polarity Setting	Overrange Output	Underrange Output	NOR Gate Output	Direction Flip-Flop	
				Up-Range	Down-Range
+	-15V	0	0	-15V	0
+	0	0	-15V	-	
+	0	-15V	0	0	-15V
-	0	-15V	0	0	-15V
-	0	0	-15V	-	-
-	-15V	0	0	-15V	0

3-8. COUNTER. (Printed Circuit Board PC-166 and Schematic Diagram 21786E). Range selection is controlled by the state of a four bit bi-directional binary counter. Input lines to the counter include: clock pulses (to cause the counter to change state), inhibit (to prevent unwanted changes of counter state) and direction (to determine counter direction during state changes). The Output line includes the output of each bit and its inverse. The first bit (flip-flop) of the counter (counter output code 1) will be explained as an example of counter operation. The circuits that control the counter outputs codes of 2 4 8 are symmetrical with the first bit and operate similarly. Refer to Schematic Diagram 21786E. For the first bit, transistors Q502 and Q503 with their associated components form the flip-flop. Diodes D501 and D502 with resistors R510 and R514, and capacitors C504 and C505, are the steering network for pulses entering the flip-flop. Resistors R511 and R513 connect the inhibit line to the flip-flop transistors. Transistor Q501 forms a buffer amplifier to prevent loading the counter. Bi-directional separation is obtained by connecting transistor Q506 as either a common-base or common-emitter amplifier connection depending on the voltage level of the direction line. If the direction line is at 0 volts, Q506 operates as a common-emitter amplifier with the counter counting in a forward direction (0000 and clock pulse generates 1000). In Table 3-3 the last four states of the counter output code given are the numbers 12 to 15. These are redundant states and are not normally used in automatic ranging operation. However, it is possible to utilize these states in local or Remote operation so that all state decoders must decode them as shown.

TABLE 3-3.
Range Counter Output Code

Binary Output (1248)	Decimal Equiv.	Range (Amperes)
0000	0	10^{-2}
1000	1	10^{-3}
0100	2	10^{-4}
1100	3	10^{-5}
0010	4	10^{-6}
1010	5	10^{-7}
0110	6	10^{-8}
1110	7	10^{-9}
0001	8	10^{-10}
1001	9	10^{-11}
0101	10	10^{-12}
1101	11	10^{-13}

3-9. AND GATE. (Printed Circuit Board PC-165 and Schematic Diagram 21785E). In automatic operation, the AND gate output and the mono-stable delay circuit determine whether a range change is to be made. The AND gate is composed of transistors Q402 through Q407 and associated resistors. The various input to the AND gate are: 1) The Read Signal which prevents range change except upon timing command. 2) The Output of NOR gate from Level Sensors which prevents range change except on an over or underrange command. 3) ZERO CHECK Button. Prevents range change during picoammeter zero checking. 4) The LOCAL RANGE Button when depressed disables automatic ranging. In automatic ranging mode, this input prevents range change when at the low sensitivity range stop with an underrange condition. 5) 10^{-13} range stop. Depressing the 10^{-13} AMPERES, FULL SCALE Range Button sets the lower sensitivity limit and prevents a range change when on 10^{-13} ampere range and an underrange command is given. 6) 10^{-2} range stop prevents range change when on 10^{-2} ampere range and an overrange command is given. See Section 2 and paragraph 3-9. If all of the above inputs except a Read Signal are at 0 volts when a Read Signal occurs, the Read Signal will be allowed through the AND gate and a range change will occur. If any of the inputs are high, i.e. less than -0.6 volt, the Read Signal will not be allowed through the AND gate and no range change will occur.

3-10. MONO-STABLE DELAY CIRCUITS (Printed Circuit Board PC-165 and Schematic Diagram 21785E): Range rate, clock pulses and delayed inhibit output. The output of the AND gate drives a mono-stable delay circuit composed of transistors Q414, Q415 and Q416. When a range change condition exists, Read pulses can appear at the output of the AND gate every 16.67 milliseconds (20 milliseconds on 50 Hz instruments). Due to basic speed of response (10% to 90% rise time) and transients generated during range change the picoammeter of the Model 419 is incapable of making range changes and settling in times this short. Therefore, an adjustable delay circuit is necessary to form settling time after each range change. To briefly explain the operation of a flip-flop, assume that the flip-flop is in a state such that Q414 = -15 volts and Q415 = 0 volts. At -15 volts Q414, through the zener diode, D404, holds the emitter of unijunction transistor Q416 at zero volts and prevents it from firing. An input pulse causes the flip-flop to change states: Q414 = 0 volts and Q415 = -15 volts. At 0 volts, Q414 allows the emitter of Q416 to rise at a rate determined by R_1 and C_1 to approximately 9 volts where Q416 fires; the output pulse of the unijunction resets the flip-flop to the state where Q414 = -15 volts. Operation of the mono-stables in the actual circuit is as follows: When a range change is wanted, a pulse comes from the AND gate and causes flip-flop no. 1 to change state. This change of state causes flip-flop no. 2 to change state and to release the timing circuit. Until flip-flop no. 1 is reset from Q416, further pulses from the AND gate will have no effect on either flip-flops no. 1 or no. 2. Change of state of flip-flop no. 2 removes the inhibit signal to the counter and releases the timing circuit found by Q420, R_2 and C_2. Approximately 300 microseconds later, unijunction transistor Q420 fires, resetting flip-flop no. 2 and supplying a clock pulse to the counter, causing it to change state and thereby changing the picoammeter range. Change of state of flip-flop #1 releases Q416 and its firing is controlled by the value of R_1C_1. Both of these values are selected by the RANGE RATE Switch. When the RANGE RATE Switch is in position 1, the time constant is also determined by the instrument range. On 10^{-2} to 10^{-9} Ampere Full Scale ranges, a solid state switch, transistor Q423, shunts R_{1A} in parallel with R_1. On 10^{-10} to 10^{-13} Ampere Full Scale ranges, R_{1A} is not in parallel with R_1 and the delay time is longer. The state of flip-flop no. 1 forms an output signal (delayed inhibit output) which occurs during range change and settling time. The delay circuit between the output and flip-flop no. 1 keeps the output at -15V for about 100 milliseconds, after the change of state of flip-flop no. 1. Therefore, if many range changes are required to reach proper range, the inhibit signal is not removed until after the final one.

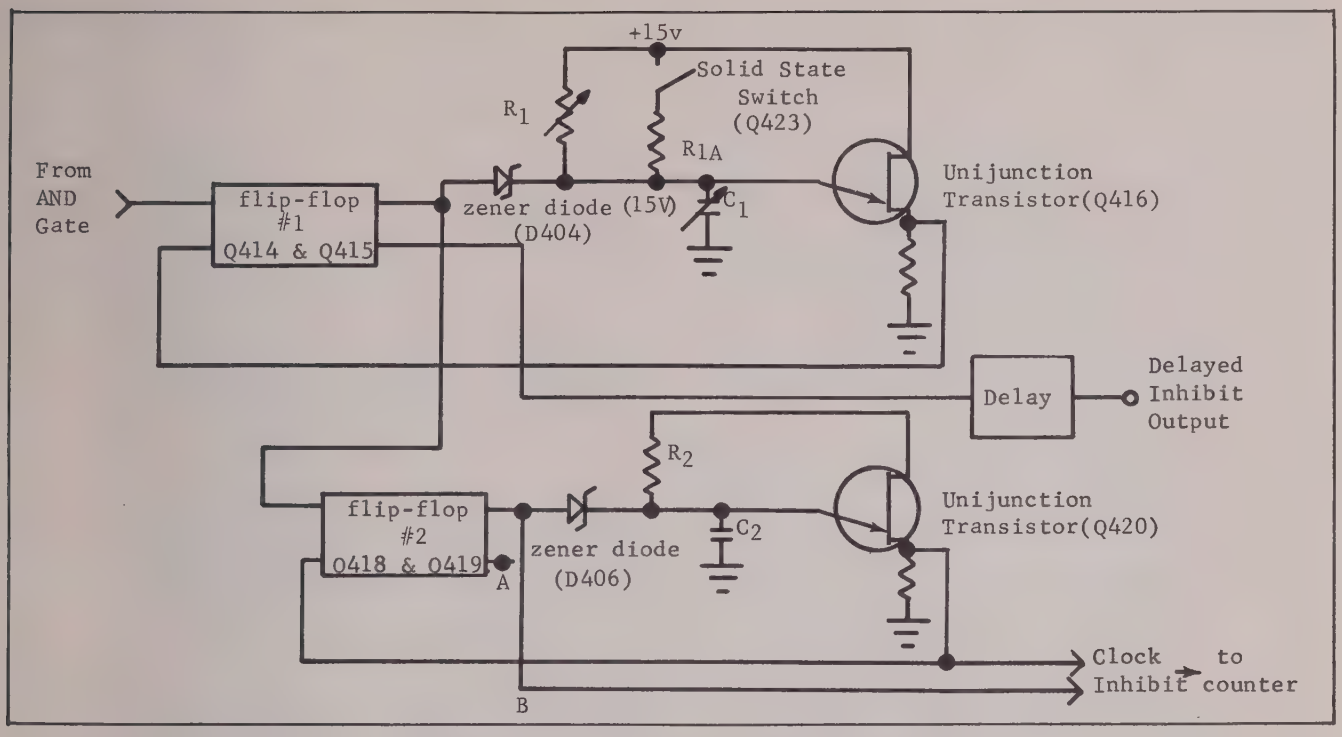


FIGURE 13. Mono-Stable Delay Circuit.

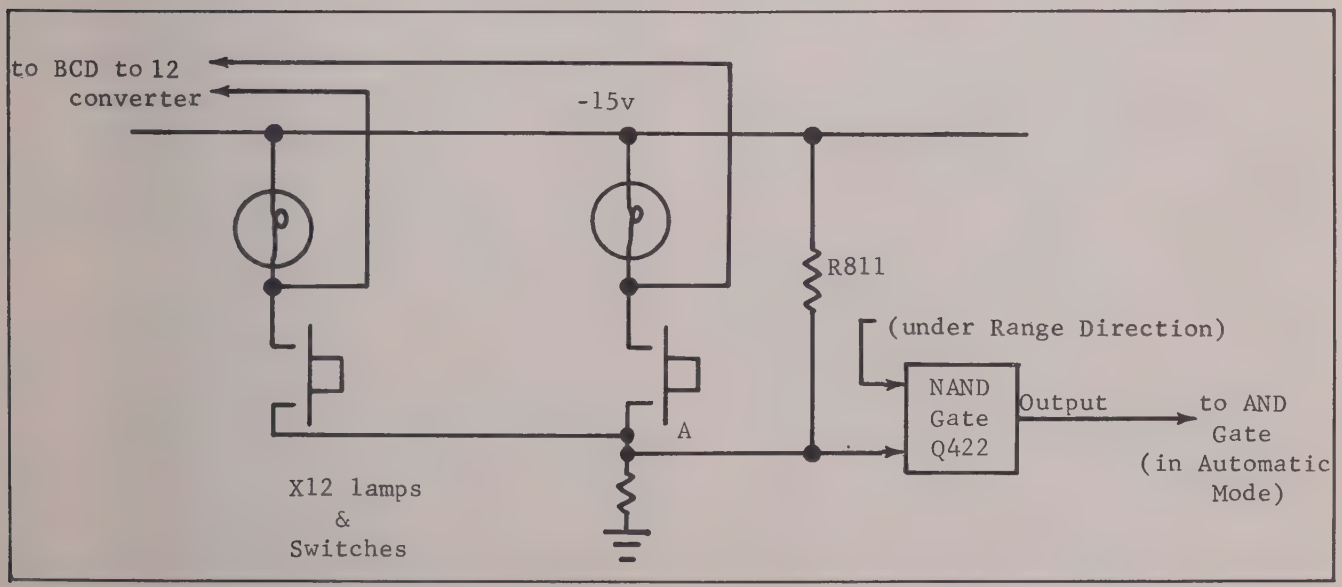


FIGURE 14. Low Sensitivity Limit Circuit.

3-11. 10^{-13} AMPERE and 10^{-2} AMPERE RANGE STOPS (Printed Circuit Board PC-165 and Schematic Diagram 21785E). In automatic operation, it is necessary to prevent the counter from going into unused states, either on the 10^{-2} ampere or the 10^{-13} ampere ends. At 10^{-2} ampere, transistor Q410 and associated components form an AND Gate to sense the 1, 2, 4, 8 code lines from the counter and overrange direction. When these conditions are all met, the instrument is on the 10^{-2} ampere range and trying to overrange. Overranging is prevented by an input to the AND gate. At 10^{-13} ampere, transistor Q411 and associated components form an AND gate to sense the 1, 2, 8 code lines from the counter and underrange direction. When these conditions are all met, the instrument is on the 10^{-13} ampere range and trying to underrange. Underranging is prevented by an input to the AND gate.

3-12. LOW SENSITIVITY LIMIT (Chassis, Printed Circuit Board PC-165 and Schematic Diagrams 21789E and 21785E). In automatic operation, it is possible to pre-set the most sensitive range by depressing the AMPERES FULL SCALE Range Button for the most sensitive range on which measurements are to be made. Range indication is accomplished by having the low terminal of the individual range indication grounded through the Binary-to-12-line converter. Point A will therefore be at some negative voltage when the range the instrument is on is not the same as the range whose button is depressed causing downranging. When the instrument is on the range whose button is depressed, Point A becomes approximately 0 volts. This signal is applied to a NAND gate, transistor Q422, along with the underrange direction signal to form a stop-range signal. This stop-range signal is applied to the AND gate in the automatic mode, stopping the downranging process. This low-sensitivity limit does not work if the pilot lamp of the depressed button is missing or open.

3-13. BINARY-TO-12-LINE CONVERTER (Printed Circuit Board PC-163 and Schematic Diagram 21783D). The counter binary output is converted to a twelve line code to operate the range indication pilot lamps. The input lines are inverted so that the complements are available. The diodes in the matrix are then used to turn off the lamp driving transistors and, therefore, the lamps.

3-14. BINARY-TO-OUTPUT CONNECTOR (Printed Circuit Board PC-164 and Schematic Diagrams 21784E and 21792E shows the 122'4 BCD Code). Range information for the external indication is available at the PRINTER OUTPUT Connector. Standard code is a two-line BCD 1, 2, 4, 8, 10. +10 and -10 volt output levels are available due to buffering of the output. Available as an accessory (Model 4192) is a converter which will supply a two-line BCD 1, 2, 2', 4 10 code.

3-15. REMOTE RANGE CONTROL (Printed Circuit Board PC-165, Chassis and Schematic Diagrams 21785E and 21789E). For remote range selection, the binary control lines which control the picoammeter range, the binary-to-output connector and the binary-to-12-line converter from the counter are switched to the remote control connector. This switching is done by relays K401 and K402. Ranges are then selected by grounding the proper control lines, either with contacts or through saturated pnp transistors.

3-16. LOCAL OPERATION (Printed Circuit Board PC-165, Chassis and Schematic Diagrams 21785E and 21789E). For pushbutton range selection from the front panel, a local ranging operation is provided. Depressing of the LOCAL RANGE Button, S805, does several things: Grounds the collector of transistor Q419 which is point A in Mono-Stable Delay Section Circuits; disables automatic operation by turning off the AND gate, transistor Q406; transfers the output of Low Sensitivity Range Stop (paragraph 3-10) to transistor Q418, which is point B in Figure 19 through a buffer amplifier, transistors Q412 and Q413; grounds the collector of transistor Q409 setting the direction flip-flop in an under-range direction. When a FULL SCALE AMPERES Range Button is depressed in Local Operation, unijunction transistor Q420 fires, advancing the counter until the Low Sensitivity Range Stop determines that the proper range has been reached.

3-17. METER AND ZERO CHECK CIRCUITS (Printed Circuit Boards PC-165, PC-167 and PC-168, Chassis, and Schematic Diagrams 21785E, 21788D and 21789E). The operation of the meter, zero check and polarity circuits are reciprocally dependent upon each other. Zero Check: The entire zero check circuitry operates from one wire which may be remotely controlled. When the ZERO CHECK Button is depressed, the pilot lamp illuminates, the picoammeter feedback is shorted via relay K901 and the frequency response is altered by relay K902. Relay K601 sets the polarity to positive so that clockwise rotation of the ZERO Control always moves the meter up-scale. To allow more accurate zeroing, the meter scale is expanded by shorting out the series meter resistance through relay K702. The AND Gate is closed to prevent range-change during zeroing. Polarity: This circuit is operated from one wire which may be remotely controlled. When a POLARITY Button is depressed the proper pilot light illuminates. The Meter terminal connections are reversed via relay K702 so that the meter reads up-scale. The input current to the level sensors is selected through relay K601. The proper output phase of the level sensors is selected by solid-state switches. Meter Scale Expansion: When the METER EXPAND Button is depressed, the series resistance of the Meter is shorted out so the 1 volt picoammeter output provides full scale deflection allowing more accurate reading of currents less than 0.3 of full scale. The correct pilot lamp is illuminated.

3-18. POWER SUPPLY (Chassis, Printed Circuit Board PC-161 and Schematic Diagrams 21789E and 21782D). The Power Supply operates from the line voltage and supplies a regulated $\pm$15 volts to the picoammeter. Each supply is current limited to prevent damage due to overload: the positive supply by resistor R102 and diode D103; the negative supply by resistor R106 and diodes D105 and D106. The two supplies do not operate independently. The +15 volt supply: A differential amplifier, transistors Q107 and Q108, compares the +15 volts to reference zener diode D108. The collector of the voltage amplifier, transistor Q105, is driven by the negative bootstrap voltage. Current amplifier transistors Q103 and Q104 drive the base of pass transistor Q802. The -15 volt negative supply is compared against the positive supply by differential amplifiers Q109 and Q110.

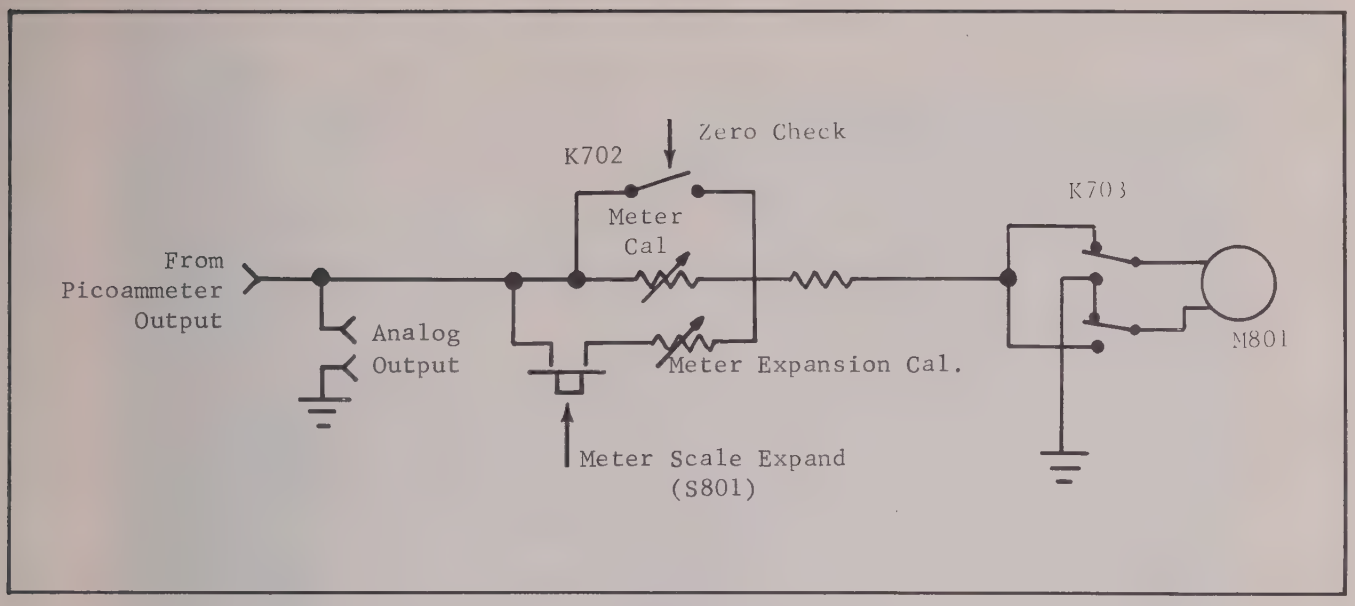


FIGURE 15. Meter Circuit

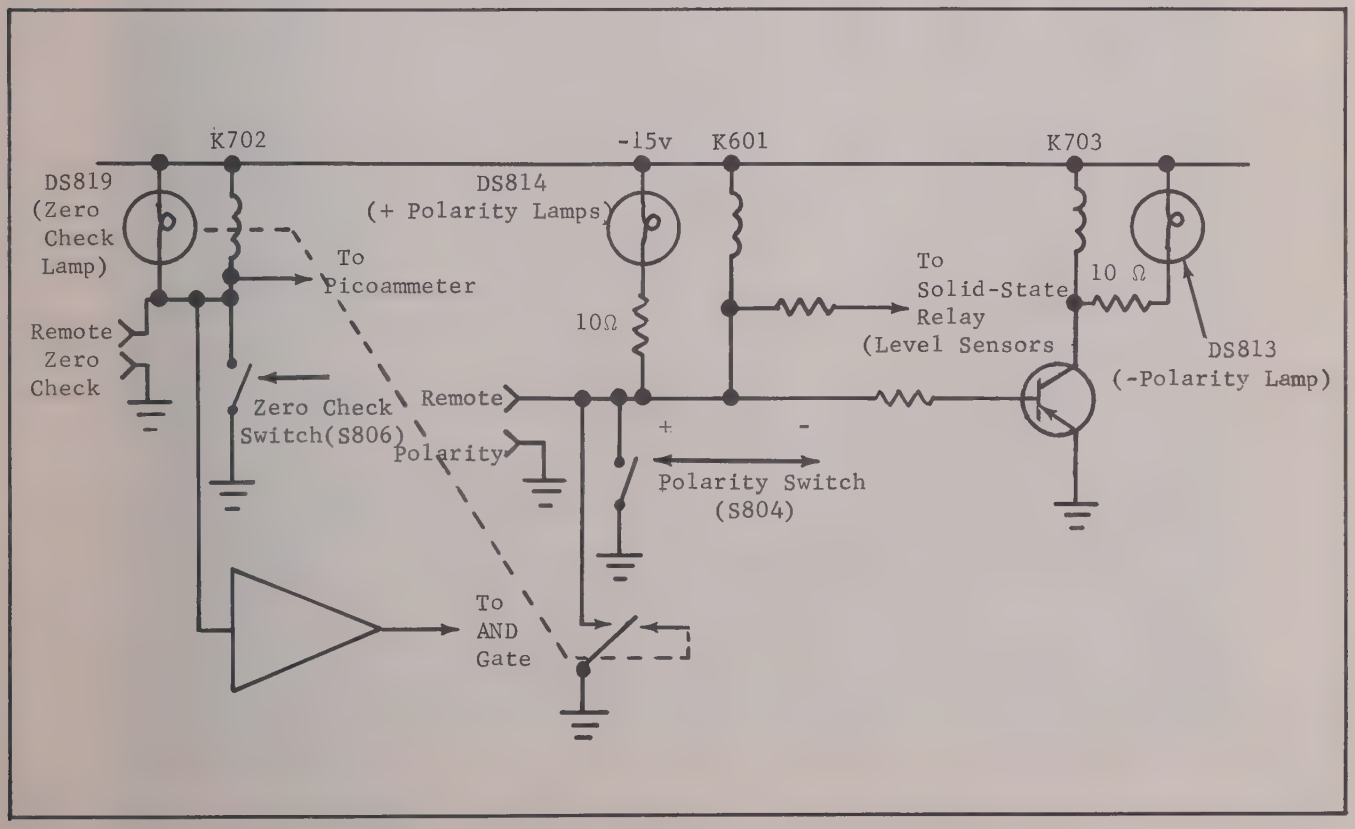


FIGURE 16. Zero Check/Polarity Circuits.

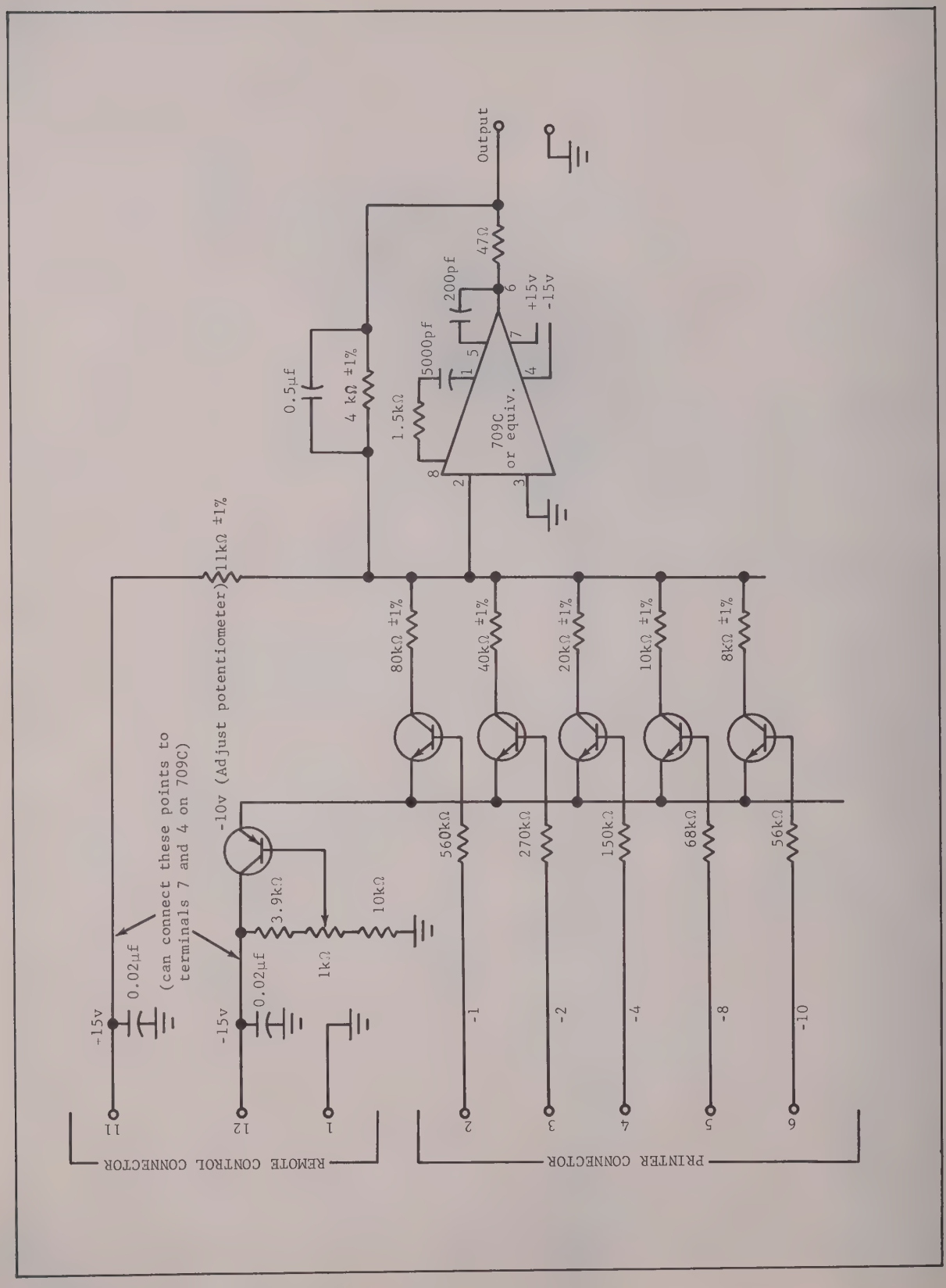


FIGURE 17. Staircase Circuit for Recording Range on Chart Recorder.

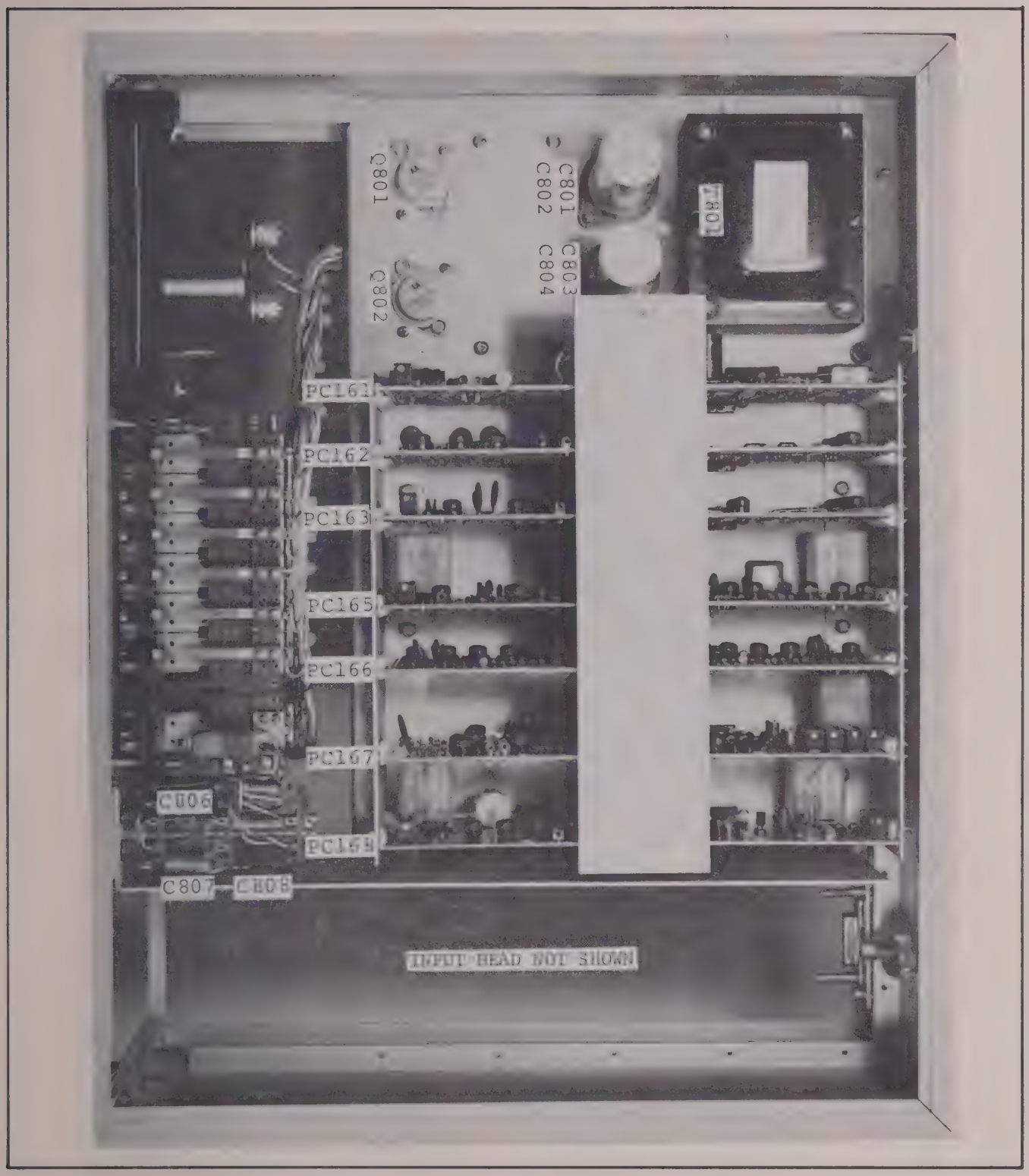


FIGURE 18. Chassis, Top View

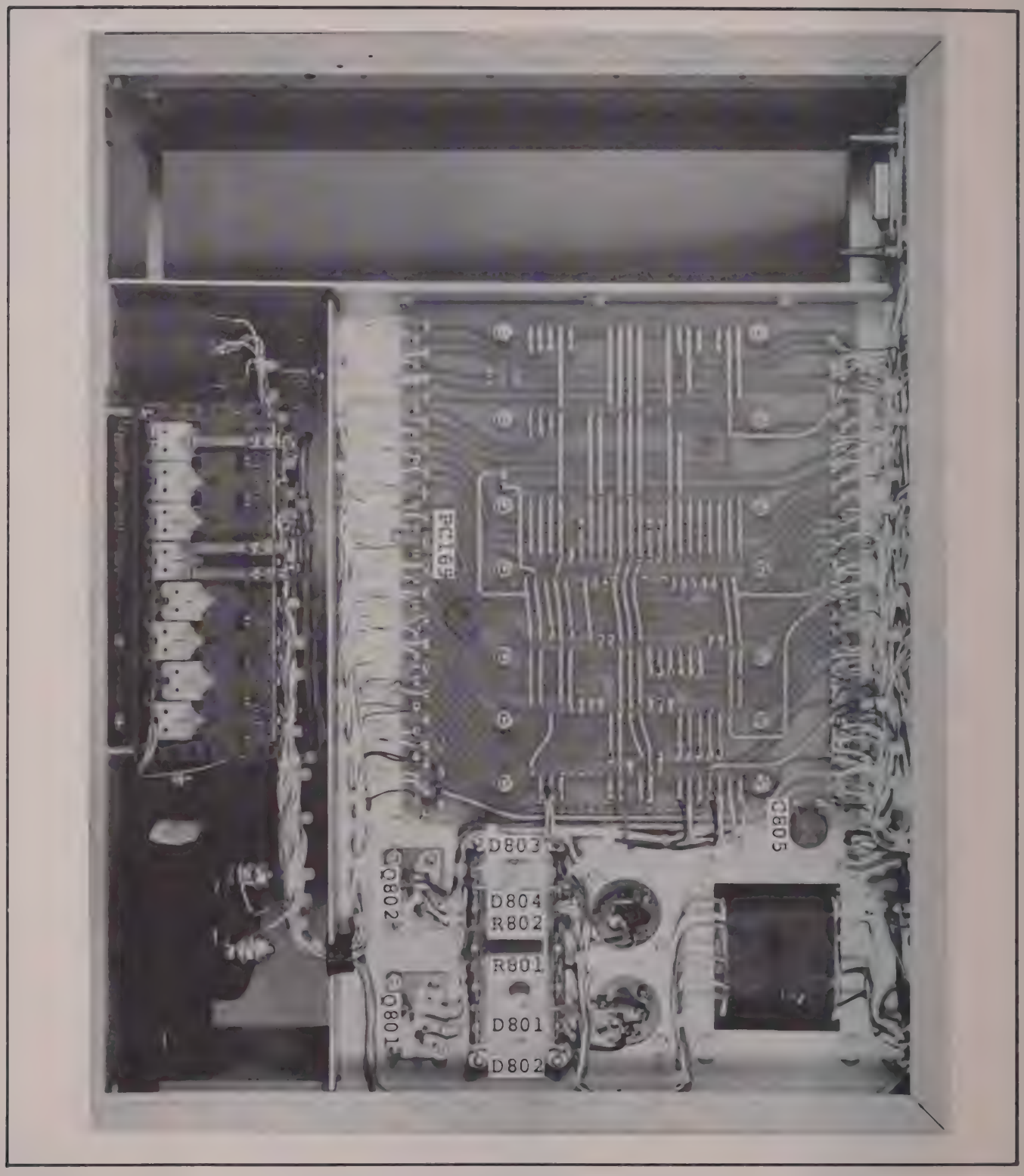


FIGURE 19. Chassis, Bottom View.

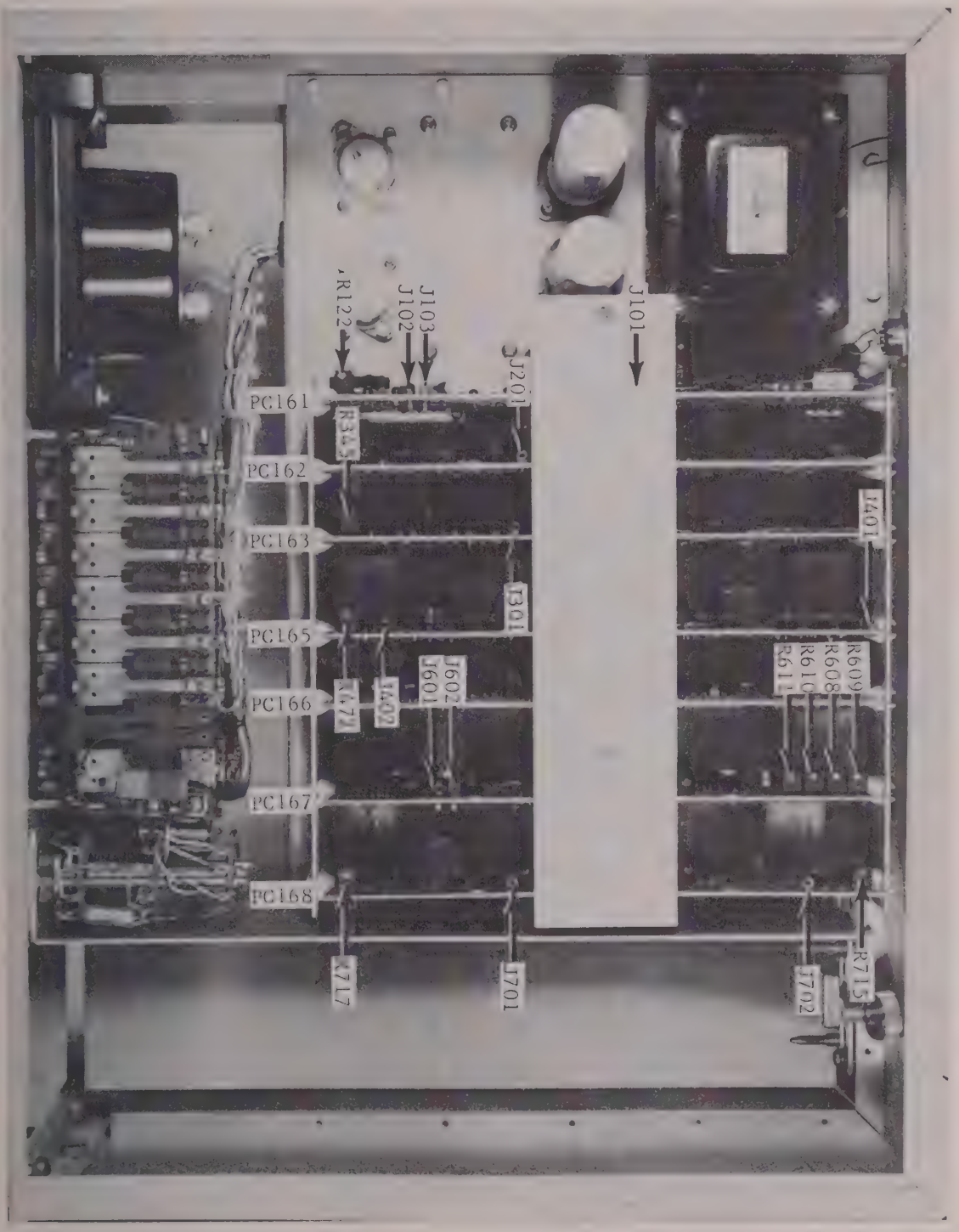


FIGURE 20. Chassis, Test Points & Adjustments.

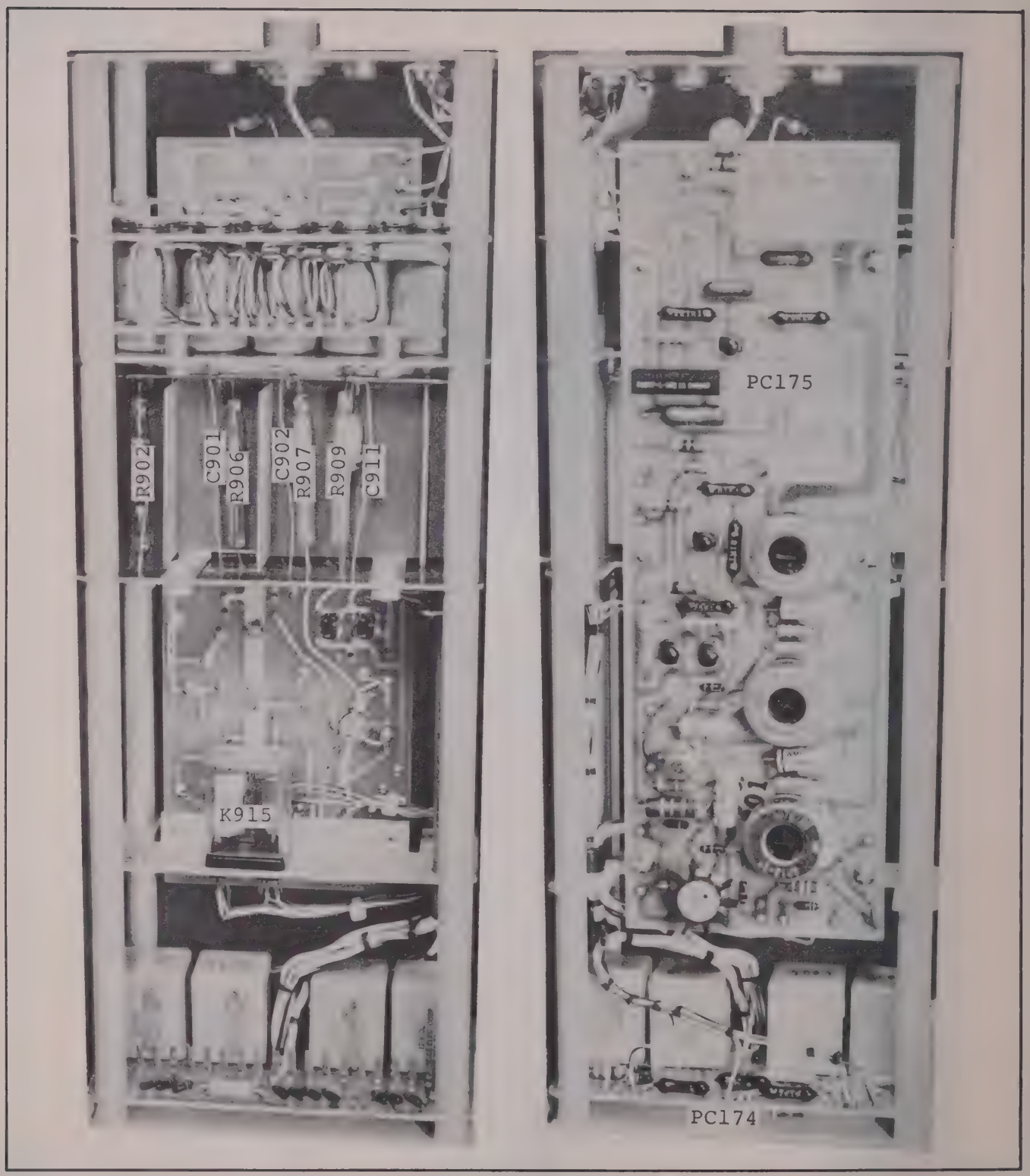


FIGURE 21. Input Head.

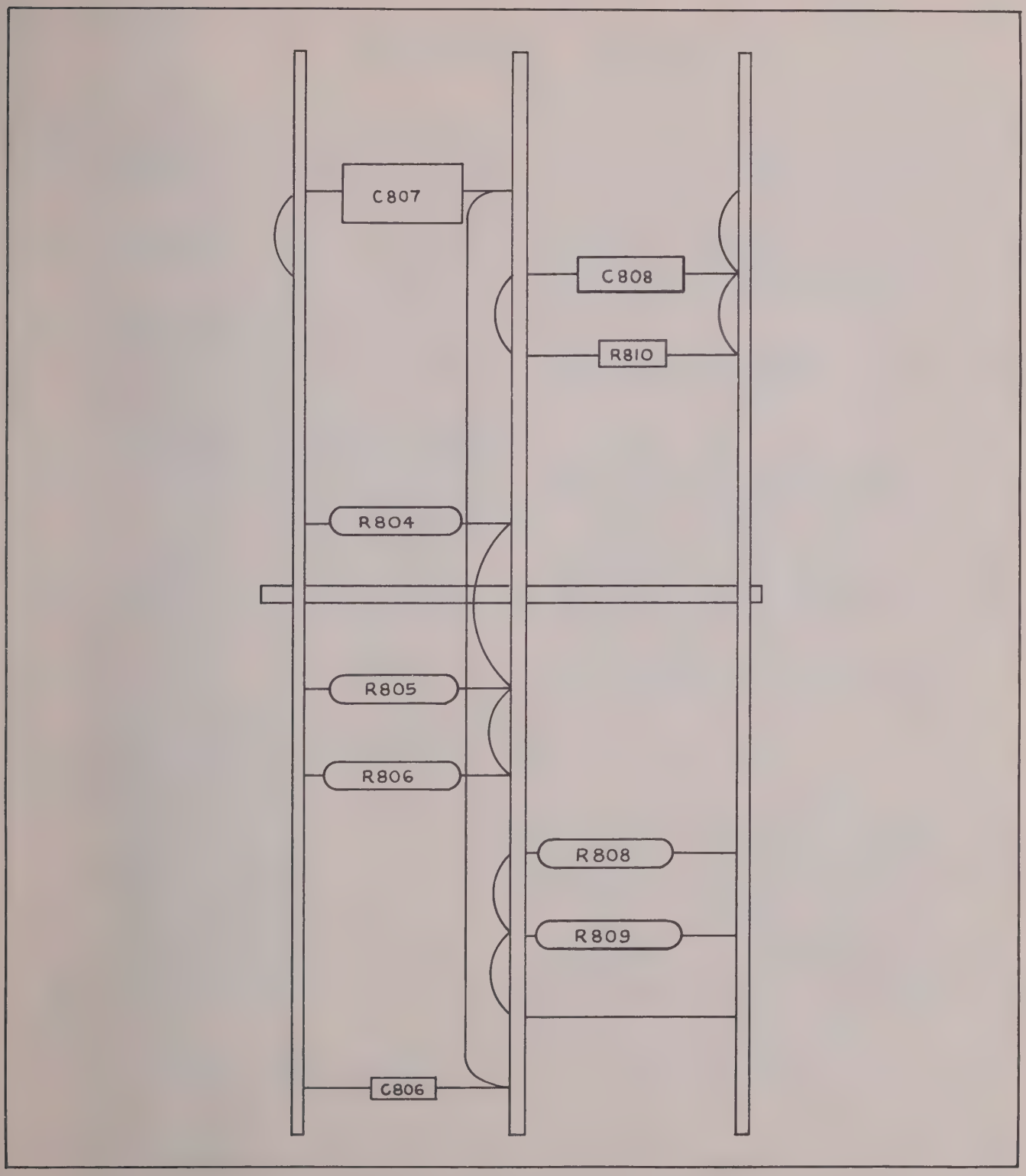


FIGURE 22. Components, Switch S802.

SECTION 4. MAINTENANCE

4-1. GENERAL.

a. The function of the maintenance section is to provide a method of checking the Model 419 to make sure that it operates properly and within the specifications given in Table 1 on page ii.

b. The following procedures are recommended for adjusting and calibrating the Model 419. Use the equipment recommended in Table 4-1. If proper facilities are not available or if difficulty is encountered, contact Keithley Instruments, Inc., or its representative to arrange for factory calibration.

c. If returning the instrument to Keithley Instruments for repair or calibration, use the Repair and Calibration form at the back of this manual. Use of this form will clarify difficulties

d. The figures at the end of this section show component layouts for the Model 419. Refer to them to find the desired components for adjusting the instrument. Refer also to the circuit description in Section 3 and the schematic diagrams at the back of the manual.

e. The Replaceable Parts List in Section 6 describes the electrical components of the Model 419. Replace components only as necessary. Use only reliable replacements which meet the specifications.

4-2. PRELIMINARY INFORMATION AND PRECAUTIONS.

a. The Maintenance section is divided into two parts. The first part, consisting of paragraphs 4-3 through 4-7, gives the checkout and calibration procedures for the Model 419 chassis without the Input Head. The second part, consisting of paragraphs 4-8 through 4-25, gives the checkout and calibration procedures of the Model 4190 Input Head mated with a calibrated chassis.

b. During the following procedures, the Model 561B Oscilloscope and Model 163 Voltmeter used must be floated above power ground.

c. During the checkout and calibration of the Model 419 chassis, logic ground (low) is used as ground for the Oscilloscope. This low is readily available on the rear of the mother pc board at the common connection of the black and white wires.

d. In the following procedures, use the Type 3A72 Dual-Trace Amplifier and Type 3B3 Time-Base as plug-in units to the Model 561B Oscilloscope. Also use two 1:1 probes, one with channel 1 (CH 1) and one with channel 2 (CH 2) on the Type 3A72. Also, unless otherwise specified, the Type 3B3 Time-Base controls are to be set as follows:

DELAYED SWEEP TRIGGERING SWITCHES	All Up (+,AC,INT)
MODE	NORM (unless otherwise specified)
DELAY TIME	020
NORM/SINGLE SWEEP/RESET	NORM

TABLE 4-1.
Test Equipment

Description	Specification	Manufacturer	Model No.
Voltmeter, True RMS	---	Ballantine	3400
Voltmeter, Digital	1 μV to 1000V 0.1%	Keithley	163
Microvolt-Ammeter	10 μV to 1000V, 10^{-1} to 10^{-11}A	Keithley	153
Picoampere Source	10^{-14} to 10^{-4}A, 0.25%	Keithley	261
Megohmmeter	10^{7} to $10^{13}\Omega$, 20%	Keithley	500
Oscilloscope, Main Frame	---	Tektronix	561B
Oscilloscope, Plug-In	---	Tektronix	3B3
Oscilloscope, Plug-In	---	Tektronix	3A72
Oscilloscope, Probe	1:1 ratio	Tektronix	
Function Generator	---	Wavetek	110
Variable Transformer	0-120V rms	Variac	--
Recorder	1 mA sensitivity	Keithley	370
Cable, Remote Amplifier	3 feet long	Keithley	4183-3
Cable, Remote Amplifier	25 feet long	Keithley	4183-25

PART ONE -- CHASSIS CHECKOUT AND CALIBRATION

4-3. PRELIMINARY PROCEDURES.

a. Remove the Model 4190 Input Head and do not plug the chassis into ac power line until specified.

b. Set the meter for zero reading with the meter mechanical zero and set the 117-234V Switch as necessary.

c. Physically check the POWER ON/OFF Button for proper operation. When depressed and released, the Button should properly activate and deactivate (audible clicks).

d. Check the resistance between logic ground and chassis ground with a Model 500 Megohmmeter. It should be greater than 10^9 ohms.

e. Depress in turn the following sequence of buttons: a) 10^{-2} through 10^{-13}, b) +, - and REMOTE +/- and c) AUTORANGE, LOCAL RANGE and REMOTE RANGE. Check that the button depressed remains depressed and that the button previously depressed automatically releases.

4-4. POWER SUPPLY CHECK.

a. Remove all the pc boards from the chassis except PC-161, the Power Supply Board.

b. Set the Model 419 front panel controls as follows:

POWER ON/OFF Button	OFF
METER ON/OFF Button	ON
Range Mode Selection Buttons	LOCAL RANGE
AMPERES, FULL SCALE Buttons	10^{-13}
RANGE RATE Switch	1
DAMPING Switch	MIN.
POLARITY Buttons	+

c. Connect the Model 163 Digital Voltmeter between ground and +15V; i.e. between the black and red jacks, respectively, on PC-161.

1. Plug the Model 419 into a Variac and set the Variac for 117 or 234 volts ac, as required. Depress the POWER ON/OFF Button.

2. Adjust the Voltage Adj. potentiometer, R122, (Figure 34) on PC-161 for a meter reading of +15 volts dc ±0.1 volt dc.

3. Connect the Model 163 between ground and -15V; i.e. between the black and green jacks, respectively, on PC-161. The meter should read -15 volts dc ±0.2 volt dc.

d. Turn the power off and insert the other pc boards.

1. Recheck the +15 and -15 volt supplies, readjusting R122 if necessary. Monitor the +15 and -15 volt supplies while varying the ac line voltage between 100 and 130 volts ac for a 117 volt instrument and between 200 and 260 volts ac for a 234 volt instrument. Neither supply should change more than 10 millivolts.

2. Check the ripple on the +15 and -15 volt supplies using the Model 561B Oscilloscope. The ripple should be less than 3 millivolts peak-to-peak. Tap potentiometer R122 and observe for spikes or an increase in noise on the +15 and -15 volt supplies. Replace R122 if necessary.

4-5. INITIAL ADJUSTMENTS.

a. Depress, in sequence, the 10^{-2} to 10^{-13} Buttons, Polarity Buttons, Range Mode Selection Buttons, ZERO CHECK, METER EXPAND, METER ON/OFF and POWER ON/OFF Buttons. Check the lamps as the buttons are depressed. With the exception of the -Polarity Button, which lights when the REMOTE +/- Button is depressed, only the button depressed should light.

b. Check the mechanical adjustment of the button switch contacts, as in the following subparagraphs, and adjust the contacts when needed.

1. Wiggle the buttons and note that they do not light or activate any discernable circuitry; i.e. another lamp, relay, etc.

2. Except for the METER EXPAND, ZERO CHECK and METER ON/OFF Buttons, depress the buttons lightly to a point where they are resistive to touch and note that they do not activate any discernable circuitry.

3. Apply 1 to 3 volts dc to Ground and Logic Ground (Terminals 3 and 9, Figure 4) at the REMOTE HEAD Receptacle with the Voltage Supply. Monitor the output at Picoammeter Output Terminal of the REMOTE HEAD Receptacle (Terminal 3, Figure 4). to 9

a) Depress the METER ON/OFF Button lightly and note that the lamp does not light nor meter

deflect until the Button has traveled approximately 1/8 inch. Depress the Button to ON.

b) Depress the ZERO CHECK Button lightly and note that the lamp does not light nor the meter deflection change until the Button has traveled approximately 1/8 inch.

c) Depress the METER EXPAND Button and note that the lamp does not light nor the meter deflection change until button has traveled approximately 1/8 inch.

c. Apply +3.00 volts to the REMOTE HEAD Connector and adjust Meter potentiometer, R717, (Figure) on PC-168 for full scale meter deflection. Check the Model 419 Polarity Button, + and -, for proper operation by switching the Model 419 to opposite polarity than above, and applying -3.00 volts. Note that the meter polarity and test fixtures are of opposite polarity.

4-6. INTEGRATOR AND LEVEL SENSORS CHECK AND CALIBRATION. During the following checks select the Model 419 polarity as necessary, and set the Model 419 controls as follows:

POWER ON/OFF Button	ON
METER ON/OFF Button	ON
Range Mode Selection Buttons	LOCAL RANGE
AMPERES, FULL SCALE Buttons	10^{-13}
RANGE RATE Switch	1
DAMPING Switch	MIN.
POLARITY Buttons	as necessary

a. Timing Pulses Check and Calibration. Set the controls on the Type 3B3 Unit to +, AC, EXT at 10 milliseconds per division. Connect the EXT TRIG Terminal to pin 18 on PC-163. Connect Channel 1 of the Type 3A72 Amplifier to pin 18 on PC-163, and set the AC/DC/GND Switch to DC and the VOLTS/DIV Switch to 10. Connect Channel 2 of the Type 3A72 Amplifier to pin 16 on PC-163, and set the AC/DC/GND Switch to AC and the VOLTS/DIV Switch to .5.

1. Lock the Oscilloscope sweep and observe the added signals of Channel 1 (one-shot input) and Channel 2 (read pulse). See Figure 23.

2. Increase the sweep of the Oscilloscope to 2 milliseconds per division and adjust the Delayed Sweep LEVEL Control so that the positive rise of the one-shot input pulse occurs 2 milliseconds (one division) after the start of the sweep.

3. Set the Time Base MODE Switch to DEL'D SWP and adjust the Delayed Sweep LEVEL Control to lock in delayed sweep. Pull out the Delayed Sweep Time Base and unlock from normal sweep. Increase the delayed sweep to 0.1 millisecond per division. Observe to see that the sweep is triggering on the leading edge of the one-shot pulse and check the time interval to read pulse. The time interval should be 0.3 millisecond. If it is not, adjust Integrator Period potentiometer, R345 (Figure 36), on PC-163 for 0.3 millisecond.

4. Relock the Delayed Sweep to normal sweep and set the MODE Switch back to NORM. Set the sweep to 10 milliseconds per division.

b. Integrator Zero Check. Keep the same setup as in sub-paragraph a above except connect Channel 1 to pin 14 on PC-168 and set the VOLTS/DIV Switch to .01.

1. Ensure that the Model 419 METER ON/OFF Button is set to ON to provide a low impedance input.

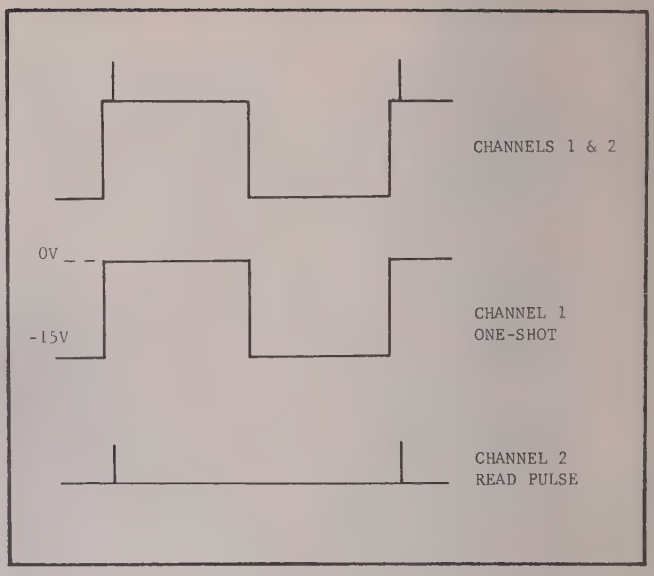


FIGURE 23. Signals for Channel 1 and Channel 2. Figure 23A shows the added signal, 23B the Channel 1 signal only (one-shot input signal) and 23C the Channel 2 signal only (read pulse signal).

2. Observe the added signals of Channel 1 (Integrator Output) and Channel 2 (Read Pulse). Set the Channel 1 AC/DC/GND Switch to AC, obtain a zero reference and then set the Switch back to DC. Observe the offset (dc shift) to x and 2x (Figure 24) which may be + or - depending on the mismatch of FETs. The maximum allowable offset between the zero reference and the Read Pulse (2x) is 30 millivolts. The Offset to x should be approximately one-half of that to 2x; approximately 15 millivolts. Nominal noise (grass) on the Integrator Output should be 4 to 5 millivolts.

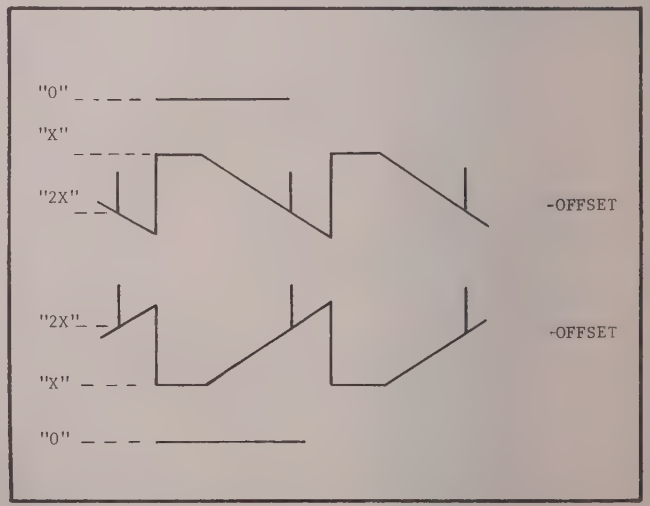


FIGURE 24. Offset to x and 2x. Figure 24A shows -offset and Figure 24B shows +offset.

3. If the 2x offset exceeds 30 millivolts, replace FETs Q703 and Q704. Before attempting any

corrective action, however, make sure that the Oscilloscope is not generating a false offset reading. The dc level of some Oscilloscopes change when the AC/DC/GND Switch is changed from GND to AC or DC. Check for this condition with no input attached to the Oscilloscope.

c. Integrator Operation Check. Keep the same setup as in paragraph b above except set the Channel 1 AC/DC/GND Switch to DC and the VOLTS/DIV Switch to 2.

1. Apply +3.00 volts to Ground and Logic Ground (Terminals 3 and 9, Figure 9) of the REMOTE HEAD Receptacle. Monitor the output at the Picoammeter Output Terminal of the Receptacle (pin 3, Figure 4) with a Model 163 Digital Voltmeter. Observe the added signals of Channel 1 and Channel 2. Repeat the test with -3.00 volts. Note that the Model 419 meter and integrator polarity are opposite of the applied voltage.

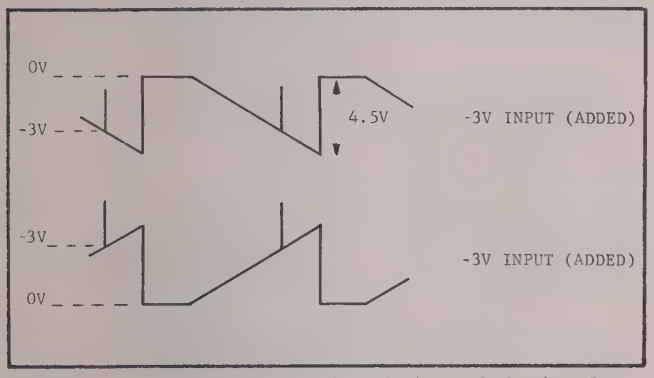


FIGURE 25. Added Channel 1 and Channel 2 Signals Obtained Applying +3V and -3V Inputs.

2. Increase the output from the Voltage Supply to approximately +8 volts. Check that the saturation level is greater than 6 volts and that no foldover occurs. Repeat this test using the opposite polarity.

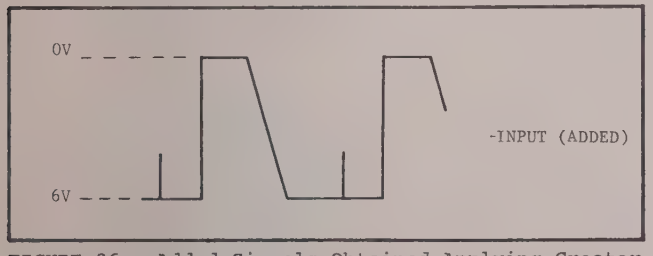


FIGURE 26. Added Signals Obtained Applying Greater than +6 Volts.

d. Level Sense Adjustments. Keep the same setup as in paragraph c above except set the sweep to 5 or 2 milliseconds per division, connect Channel 1 to pin 16 (high) or pin 15 (low) on PC-167, set the AC/DC/GND Switch to DC and the VOLTS/DIV Switch to 5.

1. Set the Model 419 POLARITY Buttons to + and apply -3.00 volts with the Voltage Supply. Connect Channel 1 to the High Sense pin (pin 16) and adjust the Positive Overrange Adj. Potentiometer R609 (Figure 39) to just trip. Note that the Model 419 trips and untrips as the voltage is varied.

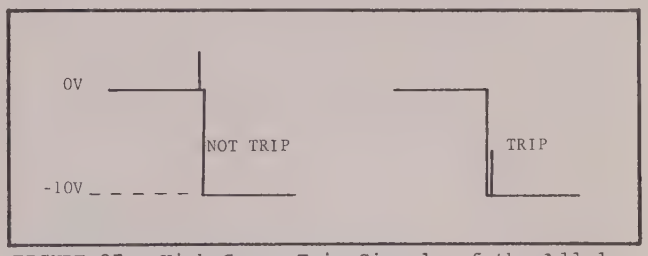


FIGURE 27. High Sense Trip Signals of the Added Signals.

2. Set the Model 419 POLARITY Button to - and apply +3.00 volts. Adjust the Negative Over-range Adj. Potentiometer, R608 (Figure 39) to just trip.

3. Keeping the same polarity, apply +.240 volts. Connect Channel 1 to the Low Sense pin (pin 15) and adjust the Negative Under-range Adj. Potentiometer, R610 (Figure 39) to just trip.

4. Reverse the Model 419 polarity and apply -.240 volts. Adjust the Positive Under-range Adj. Potentiometer, R611 (Figure 39), to just trip.

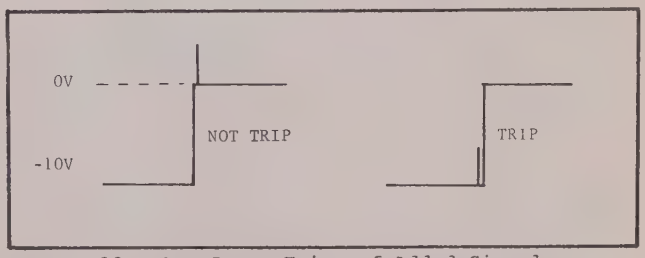


FIGURE 28. Low Sense Trips of Added Signals.

4-7. RANGING RATES AND LIMIT GATES CHECK. Set the Type 3B3 Unit DELAYED SWEEP TRIGGERING Controls to -, AC, INT at 50 milliseconds per division. Connect Channel 1 of the Type 3A72 Unit to the collector of transistor Q414 (Figure 37), the AC/DC/GND Switch to DC and the VOLTS/DIV. Switch to 10. Connect Channel 2 to pin 16 on PC-163, set the AC/DC/GND Switch to AC and the VOLTS/DIV. Switch to .5.

a. Set the Model 419 front panel controls as follows:

POWER ON/OFF Button	ON
METER ON/OFF Button	ON
Range Mode Selection Buttons	AUTO RANGE
AMPERES, FULL SCALE Buttons	10^{-13}
RANGE RATE Switch	1
DAMPING Switch	MIN.
POLARITY Buttons	+

b. Rate Pulse Check with the RANGE RATE Switch at 1 and DAMPING Switch at Maximum. Jumper the base of transistor Q404 (Figure 37) to ground (i.e. jumper R423 to the positive side of C408), and short the base to the emitter of transistor Q423. Apply greater than 3 volts from the Voltage Supply to Ground and Logic Ground of the REMOTE HEAD Re-

ceptacle. Lock the Oscilloscope sweep and observe the added signals. Adjust the Range Rate Potentiometer, R472 (Figure 37), for a time interval of 240 milliseconds (60 cycle units) or 280 milliseconds (50 cycle units) between the trailing edge of the first pulse and the leading edge of the second pulse. Maximum allowable limits are 220 to 260 milliseconds (60 cycles) and 260 to 300 milliseconds (50 cycles).

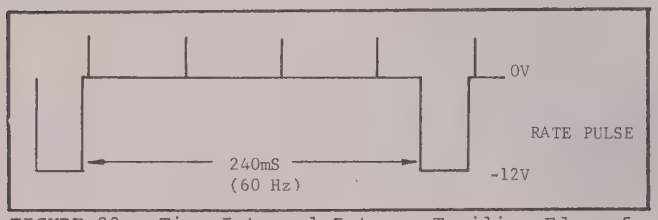


FIGURE 29. Time Interval Between Trailing Edge of First Pulse and Leading Edge of Second Pulse with RANGE RATE Switch at 1 and DAMPING Control at Maximum.

c. Rate Pulse Check with the RANGE RATE Switch at 1 and the DAMPING Control at MIN. Keep the same setup above except change the sweep to 20 milliseconds as per division.

1. Short the collector to the emitter of transmitter Q423 and apply greater than 3 volts with the Voltage Supply.

2. Lock the Oscilloscope sweep and observe the added signal. The time interval between the trailing edge of the first pulse and the leading edge of the second pulse will fall between 80 and 115 milliseconds for 60 cycle units and 100 to 140 milliseconds for 50 cycle units.

3. If the time interval does not fall within the limits, adjust the Range Rate Potentiometer, R472, to obtain the time interval. Then repeat the procedure in 4-7b to ensure that the interval falls within the maximum allowable limits.

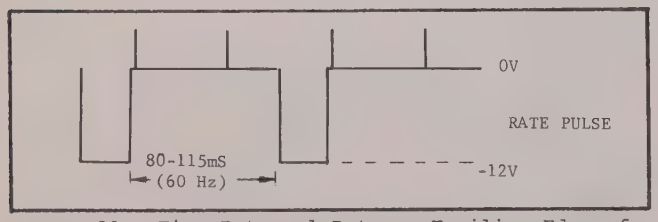


FIGURE 30. Time Interval Between Trailing Edge of First Pulse and Leading Edge of Second Pulse with RANGE RATE Switch at 1 and DAMPING control at MIN.

d. Rate Pulse Check with the RANGE RATE Switch at 2 and the DAMPING Control at MIN. Keep the same setup as in subparagraph c above except set the Model 419 RANGE RATE Switch to 2 and use a 0.1 second per division sweep.

1. Apply greater than 3 volts with the Voltage Supply.

2. Lock the Oscilloscope sweep and observe the added signals. The time interval between the leading edges of the pulses must fall between 0.5 and 0.8 seconds.

3. Note the sequence of the lamps lighting. They should light as follows: 10^{-2}, 10^{-13}, 10^{-12}, 10^{-11}, 10^{-10}, 10^{-9}, etc. to 10^{-2} and then repeat.

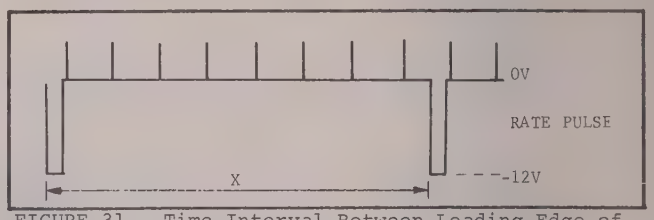


FIGURE 31. Time Interval Between Leading Edge of Pulses with the RANGE RATE Switch at 2 and the DAMPING Control at MIN.

e. Rate Pulse Check with RANGE RATE Switch at 3 and DAMPING Control at MIN.

1. Use the same setup as in subparagraph d above except set the Model 419 RANGE RATE Switch to 3 and use a 0.2 or 0.5 seconds per division sweep.

2. The same procedures as in subparagraph d above apply here except the time interval between the leading edges of the pulses should fall between 1.3 and 2.3 seconds.

f. Rate Pulse Check with RANGE RATE Switch at 4 and DAMPING Control at MIN.

1. Use the same setup as in subparagraph e above except set the Model 419 RANGE RATE Switch to 4 and use a 1 second per division sweep.

2. The same procedures as above apply here except the time interval between the leading edges of the pulses should fall between 3 and 6 seconds.

g. AND Gate Pulse Check. Use the same Model 419 control settings as above except set the RANGE RATE Switch to 1. Set the Time-Base Unit controls to +, AC, INT at a 50 microseconds per division sweep. Connect Channel 1 of the Type 3A72 Unit to the collector of transistor Q407 (Figure 37), the AC/DC/GND Switch to DC and the VOLTS/DIV. Switch to 5. Do not use Channel 2 for this check and set the AC/DC/GND Switch to GND.

1. Apply greater than 3 volts with the Voltage Supply.

2. Lock the Oscilloscope sweep, then increase the sweep to 2 microseconds per division and observe the Channel 1 signal. Make sure that part of the leading edge of the pulse can be observed.

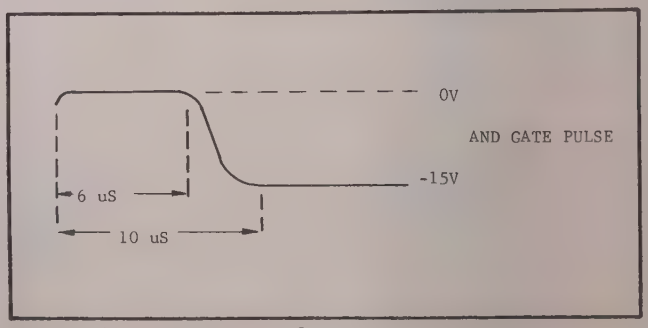


FIGURE 32. AND Gate Pulse.

3. Less than a 2 microsecond up-time and greater than an 8 microsecond drop-time is not satisfactory. Nominal values are listed in Figure 32. Values around these should be observed.

4. Once the check is finished, remove the jumper from the base of transistor Q404 to ground.

h. Delayed Inhibit Output Check.

1. Set the Model 419 front panel controls as follows:

POWER ON/OFF Button	ON
METER ON/OFF Button	ON
Range Mode Selection Buttons	AUTO RANGE
AMPERES, FULL SCALE Buttons	10^{-3}
RANGE RATE Switch	1
DAMPING Switch	MIN.
POLARITY Buttons	+

2. Set the 3B3 Time-Base Unit controls to +, AC, EXT at a 20 millisecond per division sweep and connect the EXT. TRIG Terminal to the collector of transistor Q414 (Figure 37). Connect Channel 1 to pin 9 of PC-165, set the AC/DC/GND Switch to DC and the VOLTS/DIV. Switch to 10. Connect Channel 2 to the collector of transistor Q414, set the AC/DC/GND Switch to DC and the VOLTS/DIV. Switch to 10.

a) Ground the input of Channel 1. Apply first 0 volts then greater than 3 volts repeatedly with the Voltage Supply and lock the Oscilloscope sweep to observe the pulse on Channel 2. When the sweep is locked, set the Channel 1 AC/DC/GND Switch back to DC and observe the added signals as the Voltage Supply is switched between 0 and greater than 3 volts. The time interval of x (shown in Figure 33) must fall between 70 and 120 milliseconds for 60 cycle units and between 85 and 140 milliseconds for 50 cycle units.

b) If the time interval of x is too long or too short, then the probable cause is a defective zener diode, D408 (Figure 37).

3. Once the Delayed Inhibit Output has been checked, set the Voltage Supply off.

i. Local Operation Check.

1. Set the Model 419 front panel controls as follows:

POWER ON/OFF Button	ON
METER ON/OFF Button	ON
Range Mode Selection Buttons	LOCAL RANGE
AMPERES, FULL SCALE Buttons	as desired
RANGE RATE Switch	1
DAMPING Switch	MIN.
POLARITY Buttons	+

2. Set the Time-Base Unit controls to +, AC, INT at a 20 or 50 milliseconds per division sweep. Connect Channel 1 of Type 3A72 to pin 1 of PC-166, set the AC/DC/GND Switch to DC and the VOLTS/DIV. Switch to 1. Ground Channel 2.

3. Depress at random the AMPERES, FULL SCALE Buttons and lock the Oscilloscope sweep. Once locked, allow approximately 30 seconds cool off period and then check the time interval for any sequence of range buttons. Different ranges will give pulse bursts of less than 20 milliseconds on up. The maximum interval observed must be less than 350 milliseconds.

4. Excessive time interval for any given range is usually due to a low beta transistor in the matrix.

PART TWO -- MODEL 4190 INPUT HEAD CHECKOUT AND CALIBRATION

4-8. PRELIMINARY PROCEDURES.

a. Set the three Rise Time Adjust Potentiometers, R903, R905 and R908 (Figure 41) completely counterclockwise. Do not connect the Model 4190 Input Head to the Model 419 Main Chassis. Set the ZERO Control to mid-range and the other Model 419 front panel controls as follows:

POWER ON/OFF Button	OFF
METER ON/OFF Button	ON
Range Mode Selection Buttons	LOCAL RANGE
AMPERES, FULL SCALE Buttons	10^{-2}
RANGE RATE Switch	1
DAMPING Switch	MIN.
POLARITY Buttons	as necessary

b. Turn the Model 419 on and note that the indication is normal, then turn the unit off.

c. Connect the Model 4190 to the Model 419 REMOTE HEAD Receptacle using a 3 foot cable.

1. Turn the instrument on and observe for signs of power supply loading or other abnormalities such as dim lamps, erratic indications, etc.

2. Observe meter for a + or - indication and adjust the Coarse Zero Potentiometer, R930 (Figure 41) for a near zero indication.

a) If the amplifier is unbalanced, select other ranges for observation to ensure that the problem is not due to the relays on the 10^{-2} or 10^{-3} ampere ranges.

b) Also, if the amplifier is unbalanced, depress the ZERO CHECK Button. If the amplifier now balances, then the problem is in the feed-

back circuit.

c) Finally, if the Coarse Zero Potentiometer, R930, does not swing sufficiently to adjust for zero, replace the electrometer tube, V901.

3. As zero is approached, depress the ZERO CHECK Button (this zeroes the amplifier, expands the meter scale and selects positive polarity), and adjust the Coarse Zero Potentiometer as near to zero as practical. Use the Model 419 ZERO Control for final adjustment to zero.

4. Depress the 10^{-2} through the 10^{-10} Buttons and note that the meter indication remains on scale. If the meter flies off scale and remains off scale for a given range, then the reed for that range may not be operating properly, or the feedback component may be opened, shorted or grounded.

d. Cap the INPUT Receptacle with a Keithley type Cap-4 or equivalent, and remove the gasket.

1. Connect the Model 419 OUTPUT Connector to the Model 7050 Digital Voltmeter and turn the instrument on.

2. Zero check the unit and depress the 10^{-12} Button.

a) Adjust the ZERO Control for 0.000 volts indication on the Model 7050.

b) Depress the 10^{-2} Button and note that the reading remains 0.000 volts.

c) Release the ZERO CHECK Button and note that the reading remains 0.000 volts.

3. Depress the 10^{-2} through 10^{-13} Buttons noting that the meter does not fly off and remain off scale. As the most sensitive ranges are approached (10^{-10} thru 10^{-13}), the grid current may be observed. The unit may peg on the 10^{-13} ampere range and then slowly come in for a grid current reading.

4. Return the unit to 10^{-2} ampere when completed.

4-9. GRID CURRENT CHECK.

a. Zero check the unit and adjust the ZERO Control for a zero indication.

b. To reduce shock first depress the 10^{-11} Button and then the 10^{-13} Button. Read the grid current from the meter, + or -. It should be less than 3×10^{-14} ampere. If the grid current is too high aging or cleaning the electrometer tube, V901, may bring it to within specifications. If necessary, replace the tube.

4-10. RINGING CHECK.

a. Depress the 10^{-10} Button and observe the output with an ac coupled Model 561B Oscilloscope set at 0.2 volt per division sweep.

b. Strike the Model 4190 handle with a pencil and observe for ringing. The ringing should dampen fairly rapidly.

c. Repeat this test with the 10^{-11}, 10^{-12} and 10^{-13} Buttons depressed. If the ringing induced does not subside satisfactorily, replace the electrometer tube.

d. Return the unit to 10^{-2} ampere when completed.

4-11. OSCILLATIONS CHECK. Use the same setup as in paragraph 4-10 except set the Oscilloscope for a 0.1 volt per division sweep.

a. Set the RANGE RATE Switch to 1, depress the 10^{-2} Button and turn the DAMPING Control from MIN. to full clockwise and then back to near MIN. Observe for oscillations as the control is rotated. Then repeat this procedure for each ampere range.

b. Set the RANGE RATE Switch to 4 and repeat the procedures outlined in subparagraph a above.

c. If oscillations are observed, change stopper resistor R924 for the 10^{-2} through 10^{-4} ampere ranges and resistor R934 or, if necessary, capacitor C922, for the 10^{-10} through 10^{-13} ampere ranges.

NOTE

Do not mistake ringing for oscillations.

d. When completed, set the RANGE RATE Switch to 1, the DAMPING Control to MIN. and depress the 10^{-2} Button.

4-12. AMPLIFIER OUTPUT SWING CHECK. Connect the Model 7050 Digital Voltmeter to the Model 419 OUTPUT Connector and set the Picoammeter front panel controls as follows.

POWER ON/OFF Button	ON
METER ON/OFF Button	ON
Range Mode Selection Buttons	LOCAL RANGE
AMPERES, FULL SCALE Buttons	10^{-2}
RANGE RATE Switch	1
DAMPING Switch	MIN.
POLARITY Buttons	as necessary

a. Current Limiting Check.

1. Connect the Model 261 Picoampere Source in series through a resistor box to the Model 4190 INPUT Receptacle.

2. Switch a 900 ohm resistor into the circuit with the resistor box and apply +30 milliamperes to the input of the Model 419. Note that the meter is on scale.

3. Decrease the value of the resistor to approximately 300 or 400 ohms until the amplifier saturates. (The amplifier saturates when the output voltage peaks out and further reduction of the resistance decreases the output). The output voltage must be greater than 3.3 volts.

4. Repeat the procedures of subparagraphs 2 and 3 with the Model 261 set for -30 milliamperes.

5. If trouble occurs, then possible causes are the transistor Q906 output stage is not supplying enough current or diodes D904 or D905 are shorted.

b. Zener Limiting Check.

1. Remove the resistor box, set the Model 261 for a 1×10^{-6} ampere current to the Picoammeter input, depress the 10^{-6} Button and note that the meter reads near full scale.

2. Increase the output of the Model 261 in 0.1 steps until the amplifier saturates. (Saturation is achieved when the output voltage no longer increases). The output voltage must be between 5.2 and 7.5 volts inclusive.

3. Repeat the procedures of subparagraphs 1 and 2 with the Model 261 set for -1×10^{-6} ampere.

4. If trouble occurs, the possible cause is open, shorted, or out of tolerance diodes D904 or D905.

4-13. TRIPS ADJUSTMENT. Keep the same setup as in 4-12b with the 10^{-6} Button depressed.

a. Apply 1×10^{-6} ampere with the Model 261 and then depress the AUTO RANGE Button on the Model 419. If the unit trips to the 10^{-5} range, then adjust the ZERO Control to trip it back to the 10^{-6} range. During the checks, use the ZERO Control to trip the unit back and forth between the 10^{-5} and 10^{-6} ranges.

b. On the 10^{-6} range and with the ZERO Control adjusted for an output voltage of less than 3.00 volts, slowly turn the Control to increase the output towards 3.00 volts. The Model 419 should trip at 3.00 volts ±0.005 volt. The best adjustment is a 2.99 volt indication just as the voltage is reaching 3.00 volts. If the trip voltage is not correct, adjust the Positive Overrange Adj. Potentiometer, R609 (Figure 39), to trip the unit at 3.00 volts ±0.005 volt.

c. On the 10^{-5} range and with the ZERO Control adjusted for an output voltage of more than .240 volts, slowly turn the Control to decrease the output towards .240 volts. The unit should trip at .240 volts ±.001 volt. If the trip voltage is not correct, adjust the Positive Underrange Adj. Potentiometer, R611 (Figure 39), to trip the unit at .240 volts ±.001 volt.

d. Repeat the procedures of subparagraph a, b and c above with -polarity on the Model 419 and -output voltage from the Model 261. Adjust the Negative Overrange and Underrange Adj. Potentiometers, R608 and R610 (Figure 39) if needed.

4-14. BLOCKING AND 10^{-2} OVERRUN CHECK. Use the same setup as in paragraph 4-13 except depress the AUTO RANGE Button and the 10^{-11} Button.

a. Apply $.1 \times 10^{-11}$ amperes with the Model 261, zero check the Model 419, and adjust the ZERO Control for zero indication.

b. Change the output of the Model 261 to 10^{-2} ampere. The Picoammeter should automatically range to the 10^{-2} range, then stop ranging with the meter indicating near full scale.

c. Return the Model 261 output to 10^{-11} ampere and note that the Model 419 automatically ranges to the 10^{-11} range. Repeat the procedures of subparagraphs b and c two or three times to ensure that the Picoammeter doesn't block (that is, that it doesn't stay saturated or reverse polarity), or jump through 10^{-2} range (that is, goes to the 10^{-13} range and counts down).

d. Depress the -POLARITY Button on the Model 419, apply a negative output with the Model 261 and repeat the above procedures.

e. If blocking occurs, then the electrometer tube, V901, is probably defective. Overrun is probably due to a low beta transistor Q410.

4-15. METER CAL AND EXPAND ADJUST. Use the same setup as in paragraph 4-14 except depress the LOCAL RANGE and 10^{-6} Buttons.

a. Apply 1×10^{-6} ampere with the Model 261 to the input and adjust the ZERO Control to obtain exactly 3.00 volts at the output. Adjust ~~the Scale Expand Potentiometer, R715~~ R-717 (Figure 40), for a full scale meter indication.

b. Reduce the Model 261 output to $.3 \times 10^{-6}$ ampere and adjust the ZERO Control for 0.900 volt at the output. Depress the METER EXPAND Button and adjust the Scale Expand Potentiometer, R715, for a full scale meter indication.

c. Zero check the unit and adjust the ZERO Control for 0.000 volts at the output when completed.

4-16. RANGE ACCURACY VERIFICATION. Use the same setup as in paragraph 4-15 except depress the 10^{-2} Button.

a. Check the 10^{-2} through 10^{-8} ranges for a range accuracy of ±1.5% (3 volts ±.045 volt) at the output. Check both polarities.

b. If the 10^{-5} through 10^{-8} ampere ranges read high or low, change the value of resistor R946 as necessary to obtain the best compromise for range accuracy. If the readings are high, then decrease the value of R946; if the readings are low, increase the value of R946.

c. Replace the applicable feedback resistors for out of tolerance ranges.

d. Check the 10^{-9} through 10^{-13} ranges for an accuracy of ±3% (3 volts ±.090 volt) at the output. On the 10^{-13} range, and in some cases on the 10^{-12} range, add the positive and negative readings and divide by two to eliminate error resulting from the grid current.

e. Before replacing applicable feedback resistors, make sure that an out of tolerance indication on the 10^{-9} through 10^{-13} ranges is not due to grid current.

4-16. METER TRACKING CHECK. Use the same setup as in paragraph 4-15.

a. Select one of the ranges 10^{-5} through 10^{-8} which has good full scale accuracy (3.00 volts at the output) and for which the meter reads full scale.

b. Set the Model 261 to 10 x (whatever range is used) and decrease the setting in steps while noting the meter indication. The meter should indicate within 1/4 of a minus division of the meter marking corresponding to the Model 261 output.

4-17. GAIN CHECK. For this check, the Model 419 must have been on at least 30 minutes to minimize drift. Set the Model 419 controls as in paragraph 4-16 except depress the 10^{-4} Button.

a. Connect a UHF tee, such as that found in the Keithley Model 6106 Electrometer Connection Kit, to the Model 419 INPUT Receptacle.

b. Connect the Model 261 output to one side of the tee and set the Picoampere Source for 10^{-4} ampere and the output to off.

c. Set the Keithley Model 153 Microvolt-Ammeter for Center Zero and to Volts R-2M. Zero the Model 153 on the 100 microvolt range and then set the instrument to 3 volts. Then connect the Microvolt-Ammeter input to the other side of the tee.

d. With the Model 261 output off, increase the

Model 153 sensitivity to the 1 millivolt range, maintaining a zero indication on the Model 153 using the Model 419 ZERO Control. Correct the drift with the Model 419 ZERO Control as needed during the checks.

e. Switch Model 261 back and forth between off and + as needed to obtain a reliable reading on the Model 153. The reading should be between .14 millivolt and .19 millivolt inclusive.

f. Repeat the procedures in subparagraph e above but switch back and forth between off and -. This reading is generally greater than the + reading.

g. If either or both readings fall outside the .14 millivolt to .19 millivolt limits, change the value of the amplifier gain resistor R933 to obtain the correct gain.

1. If the reading is less than .14 millivolt, then the gain is too high. Therefore, increase the value of R933.

2. If the reading is more than .19 millivolt, the gain is too low. Therefore, decrease the value of R933.

3. Allow at least a 10 minute stabilization warm-up before rechecking the gain after changing the value of R933. In some units, a longer warm-up may be required to obtain reliable readings.

h. Optimum gain is a reading of .16 millivolt. However, due to the difference in + and - gain readings in most units, a compromise is necessary to maintain both readings within the .14 millivolt to .19 millivolt limits.

4-18. 10^{-12} AND 10^{-13} AMPERE RANGES RISE TIME CHECK WITH A 3-FOOT CABLE.

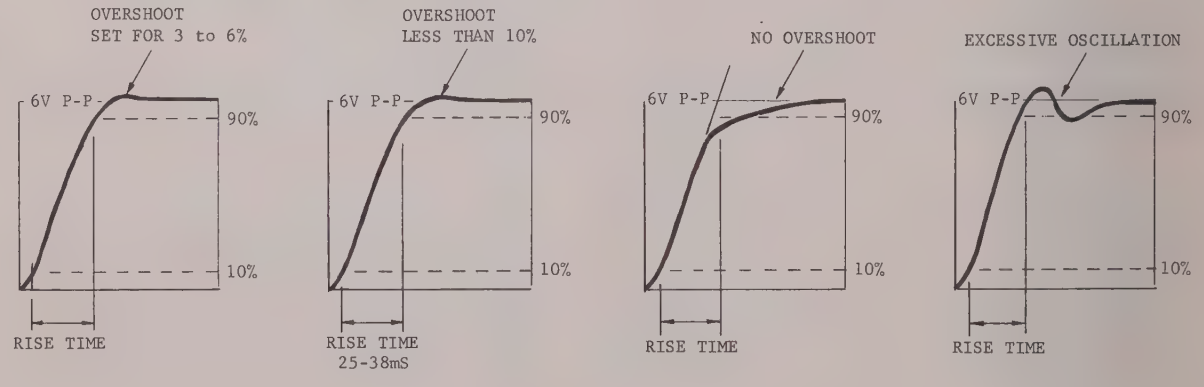
a. Set the Model 419 controls as follows:

POWER ON/OFF Button	ON
METER ON/OFF Button	OFF
Range Mode Selection Buttons	LOCAL RANGE
AMPERES, FULL SCALE Buttons	10^{-2}
RANGE RATE Switch	1
DAMPING Switch	MIN.
POLARITY Buttons	as necessary

b. Connect the OUTPUT connector to a dc coupled Model 561B Oscilloscope set at 1 volt per division.

c. Connect the output of a Wavetek Model 102 Function Generator to a 10:1 divider. Connect the divider through a 5 picofarad shielded capacitor to the Model 419 INPUT Receptacle. Apply a 1.5 Hz sawtooth signal with the Generator.

d. Depress the 10^{-12} Button and adjust the Generator amplitude for a 6 volts peak-to-peak output from the Model 419.



(a) Satisfactory Overshoot. (b) Satisfactory Rise Time. (c) Improper Rise Time- No Overshoot. (d) Improper Response- Excessive Oscillation.

FIGURE 33. Waveforms for 10^{-12} Rise Time Check.

1. Set the 10^{-12} Rise Time Potentiometer, R903 (Figure 41), completely counterclockwise. Adjust the slide on the resistor for the 10^{-12} ampere range, R902, to obtain approximately a 3 to 6% overshoot similar to that shown in waveform A, Figure 33.

2. Adjust the 10^{-12} Rise Time Potentiometer, R903, to obtain a 25 to 38 millisecond 10-90% rise time similar to that shown in waveform B, Figure 33. Overshoot should be less than 10%.

3. Waveform C in Figure 33 shows improper adjustment. While the 10-90% rise time appears to be 35 milliseconds, the actual rise time (dotted line) is 20 milliseconds.

4. Waveform D shows another type of improper adjustment. Some dipping, particularly in other ranges than 10^{-12} ampere, may be experienced. The dip, however, should not be more than 5% below the 100% (6 volt) indication (dotted line).

e. Set the Model 419 RANGE RATE Switch to 4 and the DAMPING Control completely clockwise. Change the divider to 1:1 and apply a .05 Hz sawtooth signal with the Function Generator. Adjust the amplitude of the Generator to obtain 6 volts peak-to-peak at the output of the Model 419.

1. Measure the 10-90% rise time. It should be between 2 and 5 seconds.

2. If the rise time is not between 2 and 5 seconds, then readjust the slide on resistor R902 as needed to obtain the proper rise time.

f. Set the RISE TIME Switch to 1 and the DAMPING Control to MIN. Check the 10^{-13} ampere range 10-90% rise time using the same setup as before except use a 100:1 divider and set the frequency for 1 Hz. The rise time should be less than 500 milliseconds.

g. Cap the Model 419 input and check output noise on the Ballantine Model 3400 RMS Voltmeter. While the maximum noise specifications are 60 millivolts on the 10^{-12} ampere range and 150 millivolts on the 10^{-13} ampere range, the noise should be less using the 3 foot cable. Noise increases when the Model 4190 is installed in the chassis. Generally, the 10^{-12} ampere range output noise should be from 40 to 55 millivolts and the 10^{-13} ampere range output noise should be from 80 to 120 millivolts using the 3 foot cable and minimum damping. If in doubt, measure the 10^{-12} and 10^{-13} ampere range noise with the Model 4190 in the chassis. Some possible causes of high noise and their solution are given in Table 4-2.

4-19. 10^{-9}, 10^{-10} and 10^{-11} AMPERE RANGES RISE TIME CHECK WITH A 3 FOOT CABLE.

a. Set the Model 419 controls as follows:

POWER ON/OFF Button	ON
METER ON/OFF Button	OFF
Range Mode Selection Buttons	LOCAL RANGE
AMPERES, FULL SCALE Buttons	10^{-2}
RANGE RATE Switch	1
DAMPING Switch	MIN.
POLARITY Buttons	as necessary

b. Connect the OUTPUT Connector to a dc coupled Model 561B Oscilloscope set at 1 volt per division.

c. Connect the output of a Wavetek Model 102 Function Generator to a 1:1 divider and connect the divider output to the input of the Model 4190 through a 5 picofarad shielded series capacitor. Set the Generator for a 25 Hz sawtooth output.

d. Depress the 10^{-9} Button and adjust the Generator amplitude to obtain a 6 volts peak-to-peak square wave output from the Model 419.

1. Check the 10-90% rise time for 5 milliseconds or less and overshoot of less than 10%.

2. If the overshoot is more than 10%, then replace capacitor C911 with another 2.2 picofarad capacitor selected for high side of tolerance.

e. Connect the output of the Generator to a 10:1 divider, depress the 10^{-10} Button and adjust the Generator for a 6 volts peak-to-peak square wave at the output of the Model 419. (Depending on the slide position of the 10^{-10} ampere range resistor,

TABLE 4-2.
Possible Causes of High Noise and their Solution.

Possible Cause	Solution
Gasket of the Model 419 Cap.	Remove the Gasket.
Ground Loops Present.	Float the RMS Voltmeter.
Power Supplies Noisy.	Check the Voltages and Ripples of the Power Supplies per Paragraph 4-4.
Fast Rise Times.	Recheck Rise Times per Paragraph 4-18.
High Gain.	Recheck Gain per Paragraph 4-17.
Transistors Q901 or Q902 Noisy.	Replace the Transistor(s) and Recheck the Gain and Rise Times.
Electrometer Tube V901 Noisy.	Replace the Tube and Recheck the Gain and Rise Times.
Reed of 10^{12} Ampere Range Resistor Vibrates, Causing Noise.	Stuff the Tube Containing the Resistor With Teflon to Eliminate Noise.

R907, the initial output may appear as more of a sawtooth than a square wave).

1. Set the 10^{-10} Rise Time Potentiometer, R908 (Figure 41), completely counterclockwise and adjust the slide on R907 to obtain the best looking square wave output. A small overshoot (less than 2%) and dip will normally be observed on the leading edge.

2. Check the 10-90% rise time for 5 milliseconds or less, adjusting Potentiometer R908 if necessary. To obtain this rise time, it may be necessary to readjust the slide on resistor R907.

f. Change the divider to 100:1, depress the 10^{-11} Button and adjust the Generator amplitude for a 6 volts peak-to-peak square wave output from the Model 419. Adjust the 10^{-11} Rise Time Potentiometer, R905 (Figure 41), to obtain a 10-90% rise time of 6 milliseconds or less. Properly adjusted, overshoot and dipping can normally be held within 5%.

4-20. RISE TIMES CHECK WITH MODEL 4190 INPUT HEAD IN MODEL 419 CHASSIS.

a. Insert the Input Head into the Model 419 Chassis and tighten the retaining screws. Make sure that the 3 foot cable is removed from the REMOTE HEAD Connector and that the gasket is removed from the input cap.

b. Set the Model 419 controls as follows:

POWER ON/OFF Button	ON
METER ON/OFF Button	OFF
Range Mode Selection Buttons	LOCAL RANGE
AMPERES, FULL SCALE Buttons	10^{-2}
RANGE RATE Switch	1
DAMPING Switch	MIN.
POLARITY Buttons	as necessary

c. Connect the Model 419 OUTPUT Receptacle to a dc coupled Model 561B Oscilloscope set at 1 volt per division.

d. Check the 10^{-2} through 10^{-8} rise times with minimum damping.

1. Connect the Signal Generator output to the input of the Model 4190 through a series resistor whose value is the reciprocal of the range to be checked; i.e., for the 10^{-2} range use a 10^{2} resistor, for the 10^{-3} range use a 10^{3} resistor, etc.

2. Set the Model 102 to a 50 Hz square wave. For each range checked, adjust the Generator amplitude for a 6 volts peak-to-peak output from the Model 419.

3. Check the 10^{-2} through 10^{-7} ranges for a rise time of less than 1 millisecond. Except for the spike on the leading edge of the 10^{-2} range, the overshoot for each range should be less than 10%.

4. For the 10^{-8} range use a 25 Hz square wave. Check the 10^{-8} range for a 10-90% rise time of less than 5 milliseconds and an overshoot of less than 10%.

5. While checking the 10^{-8} range, switch the RANGE RATE Switch to 4 and set the DAMPING Control completely clockwise.

a) Set the Generator frequency to .05 Hz and adjust the amplitude, if needed, to obtain a 6 volts peak-to-peak output from the Model 419.

b) Check the 10-90% rise time for 2 to 5 seconds.

e. Return the RANGE RATE to 1 and the DAMPING Control to MIN.

1. Connect the Generator output to a divider box and then through a shielded series 5 picofarad capacitor to the input of the Model 419.

2. Use the sawtooth frequency and divider box setting listed in Table 19 to check the 10-90% rise time of the 10^{-9} through 10^{-13} ranges. For each range, adjust the amplitude of the Generator to obtain a 6 volts peak-to-peak output from the Model 419.

3. If any range is out of tolerance, readjust it per the previous procedure using the 3 foot cable.

f. Set the RANGE RATE Switch to 4, the DAMPING Control completely clockwise, and recheck the rise times of the 10^{-9} through 10^{-12} ranges.

1. Use the same setup as in subparagraph e above except use the series capacitor and the divider setting listed in Table 4-4.

2. Also for this check, use a .05 Hz sawtooth signal from the Generator. Adjust the amplitude of the Generator to obtain a 6 volts peak-to-peak output from the Model 419.

TABLE 4-3.
10^{-9} through 10^{-13} Rise Time Checks Using Various Generator Sawtooth Frequencies. The Table shows the range checked, the frequency applied, the divider setting and the maximum rise time and overshoot to be expected.

Range	Sawtooth (Hz)	Divider	Maximum 10-90% Rise Time	Maximum Overshoot
10^{-9}	25	1:1	5 mS	<10%
10^{-10}	25	10:1	5 mS	<10%
10^{-11}	25	100:1	6 mS	<10%
10^{-12}	1.5	10:1	40 mS	<10%
10^{-13}	1.0	100:1	500 mS	<10%

TABLE 4-4.
10^{-9} through 10^{-12} Rise Time Check Using Generator Frequency of .05 Hz.

Range	Series Capacitor	Divider	10-90% Rise Time (Seconds)
10^{-9}	5000 pF	1:1	2 to 5
10^{-10}	500 pF	1:1	2 to 5
10^{-11}	500 pF	10:1	2 to 5
10^{-12}	500 pF	100:1	2 to 5

4-21. IN CHASSIS NOISE CHECK.

a. Set the Model 419 controls as follows:

POWER ON/OFF Buttons	ON
METER ON/OFF Buttons	ON
Range Mode Selection Buttons	LOCAL RANGE
AMPERES, FULL SCALE Buttons	10^{-2}
RANGE RATE Switch	1
DAMPING Switch	MIN.
POLARITY Buttons	as necessary

b. Cap the input and connect the output to a Model 3400 RMS Voltmeter.

c. Check the output noise on the 10^{-2} through 10^{-12} ranges for less than 60 millivolts and the 10^{-13} range for less than 150 millivolts.

d. Also check the 10^{-12} and 10^{-13} ranges while tapping the edge of the bench with a pencil. The noise should not rise appreciably.

e. While on the 10^{-13} range, check the grid current for less than 3 x 10^{-14} ampere. Also observe the meter noise. Excluding shifts and kicks, the meter noise should be about 1 to 1-1/2 minor divisions on the top scale.

4-22. IN CHASSIS RECOVERY CHECK.

a. Set the Model 419 controls as follows:

POWER ON/OFF Button	ON
METER ON/OFF Button	OFF
Range Mode Selection Buttons	LOCAL RANGE
AMPERES, FULL SCALE Buttons	10^{-12}
RANGE RATE Switch	1
DAMPING Switch	MIN.
POLARITY Buttons	as necessary

b. Connect the output of the Model 419 to a dc coupled Model 561B Oscilloscope set at 2 volts per division.

c. Place a 50 picofarad shunt capacitor on the INPUT Receptacle of the Model 4190.

1. Select the 10^{-12} Button, depress the ZERO CHECK Button and then release. Measure the time the amplifier remains in saturation.

2. Select the 10^{-13} Button and repeat the procedure.

TABLE 4-5.
Recovery Time Checks

Range	Maximum Recovery Time 50 pF	500 pF
10^{-12}	1 second	10 seconds
10^{-13}	10 seconds	60 seconds

d. Repeat the procedures of subparagraph c using a 500 picofarad shunt capacitor on the input. Table 4-5 lists the desired results in each test.

4-23. RISE TIME CHECK WITH A 25 FOOT CABLE.

a. Set the Model 419 controls as follows:

POWER ON/OFF Button	ON
METER ON/OFF Button	OFF
Range Mode Selection Buttons	LOCAL RANGE
AMPERES, FULL SCALE Buttons	10^{-2}
RANGE RATE Switch	1
DAMPING Switch	MIN.
POLARITY Buttons	as necessary

b. Remove the Model 4190 Input Head from the Model 419 Chassis and connect it to the Chassis REMOTE HEAD Connector with a 25 foot cable.

c. Check the rise times of the 10^{-9} through 10^{-13} ranges using the same setup as in paragraph 4-20e, except check them to the figures given in Table 4-6.

TABLE 4-6.
10^{-9} through 10^{-13} Ranges Rise Time Check Using 25 Foot Cable.

Range	Maximum 10-90% Rise Time (milliseconds)
10^{-9}	6
10^{-10}	8
10^{-11}	8
10^{-12}	80
10^{-13}	700

d. The 10^{-2} through 10^{-8} rise times and the maximum damping rise time checks are not required using the 25 foot cable.

4-24. NOISE AND OSCILLATIONS CHECK WITH A 25 FOOT CABLE.

a. Check the output noise using the procedures outlined in paragraph 4-21. With a 25 foot cable, the noise is typically less than with the Input Head mounted in the Chassis.

b. Check the oscillations using the same procedures outlined in paragraph 4-11.

4-25. DRIFT CHECK.

a. The unit must be off for at least 2 hours prior to starting a drift run.

b. Cap the input and set the Model 419 controls the same as in paragraph 4-23 except depress the METER ON/OFF Button for ON and the AMPERES, FULL SCALE Buttons to 10^{-10}.

c. Connect the OUTPUT Receptacle to a recorder and set the recorder attenuator to 0.1 for 100 millivolts full scale on the recorder.

d. Zero the unit as needed during a 30 minute warm-up. After the warm-up, the Model 419 must drift less than 30 millivolts per 24 hours.

SECTION 5. ACCESSORIES

Model 3000 Bench Mounting Kit

Description:

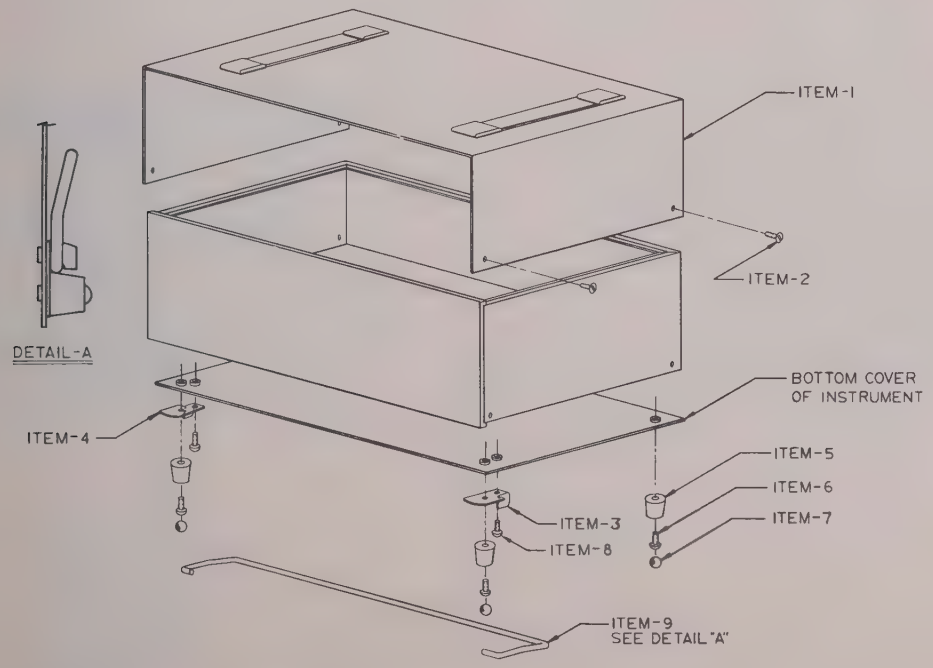
The Model 3000 is a bench mounting kit for use with instruments 5-1/4" high x 17-1/2" wide x 13-1/2" deep. All parts are included for conversion of a rack mounted instrument to bench mounting complete with top cover, handle assembly, non-skid feet and tilt bail assembly.

Parts List:

Item No.		Qty. Per Assembly	Keithley Part No.
1	Cover Assembly	1	14562B
2	Screw, Slotted 10-32x1/4	4	-
3	Bail Support, Right	1	19206B
4	Bail Support, Left	1	19205B
5	Foot, plastic	4	FE-5
6	Screw, Phillips, 8-32x3/8	4	-
7	Rubber Foot Insert	4	FE-6
8	Screw, Phillips, 6-32x1/4	2	-
9	Tilt Bail	1	14704B

Assembly:

1. Remove the rack angles attached to the rack mounted instrument. The four 10-32 slotted screws supplied with the instrument should be used to install the bench-style top cover (item 1).
2. Remove the bottom cover to facilitate the mounting of the non-skid feet and tilt bail assembly. Use a screw driver to turn the pawl-type fasteners on the cover (about one-half turn clockwise).
3. Install the bail supports (items 3 and 4) using 6-32 screws (item 8).
4. Install the plastic feet (item 5) using 8-32 screws (item 6) in four places.
5. Install tilt bail (item 9) as shown.
6. Install bottom cover using pawl-type fasteners.



Model 4172 Remote Housing

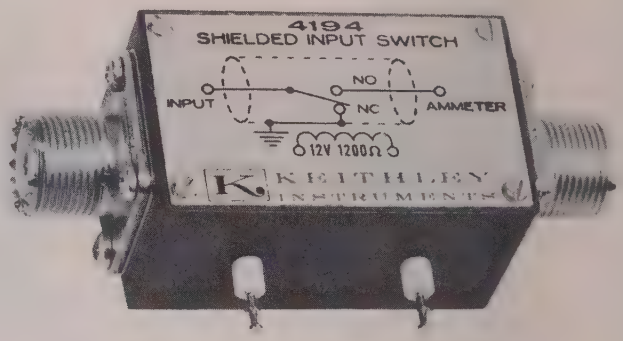
Description: The Model 4172 is an accessory housing useful when locating the Model 4190 Input Head in a remote location.

Model 4183 Remote Amplifier Cable

Description: The Model 4183 is an accessory cable useful when the Model 4190 Input Head is located at distances up to 25 feet. Specify either 10 ft. or 25 ft. length when ordering.

Model 4194 Shielded Input Switch

Description: The Model 4194 is a remotely controlled reed switch that permits shorting of the input during sample changes, etc. The switch is useful in automated testing when it is important to keep the source input shorted when not being measured.



Model 261 Picoampere Source

Description:

The Model 261 is an accurate picoampere current source with 3 digit resolution. The output ranges are 10^{-14} ampere to 1.1 x 10^{-4} ampere, positive or negative, in eight decade ranges. Accuracy is rated rom $\pm$.25% to $\pm$1.6% exclusive of input drop considerations.

Application:

The Model 261 is a secondary standard for use in calibrating picoammeters and electrometers. It can also be used as an accurate current source for zero suppression and for galvanometric measurements.

SECTION 6. REPLACEABLE PARTS

6-1. REPLACEABLE PARTS LIST. This section contains a list of components used in this instrument for user reference. The Replaceable Parts List describes the individual parts giving Circuit Designation, Description, Suggested Manufacturer (Code Number), Manufacturer Part Number, and the Keithley Part Number. Also included is a Figure Reference Number where applicable. The complete name and address of the Manufacturers is listed in the CODE-TO-NAME Listing following the parts list.

TABLE 6-1.
Abbreviations and Symbols

A	ampere	F	farad	Ω	ohm
		Fig.	Figure		
CbVar	Carbon Variable			p	pico (10^{-12})
CerD	Ceramic Disc	GCb	Glass enclosed Carbon	PC	Printed Circuit
Cer Trimmer	Ceramic Trimmer			Poly	Polystyrene
Comp	Composition	k	kilo (10^{3})		
				Ref.	Reference
DCb	Deposited Carbon	μ	micro (10^{-6})		
Desig.	Designation			TCu	Tinner Copperweld
		M	Meg (10^{6})		
EAL	Electrolytic, Aluminum	Mfg.	Manufacturer	V	volt
ETB	Electrolytic, tubular	MtF	Metal Film		
ETT	Electrolytic, tantalum	My	Mylar	W	watt
				WW	Wirewound
		No.	Number	WWVar	Wirewound Variable

6-2. ELECTRICAL SCHEMATICS AND DIAGRAMS. Schematics and diagrams are included to describe the electrical circuits as described in Section 3. Refer to Table 6-2 which identifies all schematic part numbers included.

6-3. HOW TO USE THE REPLACEABLE PARTS LIST. This Parts List is arranged such that the individual types of components are listed in alphabetical order. The parts for the instrument's Main Chassis are listed followed by printed circuit boards and other sub-assemblies. Refer to Table 6-2 for listing of circuit designation series assigned to each major sub-assembly.

6-4. HOW TO ORDER PARTS.

a. Replaceable parts may be ordered through the Sales Service Department, Keithley Instruments, Inc. or your nearest Keithley representative.

b. When ordering parts, include the following information.

1. Instrument Part Number
2. Instrument Serial Number
3. Part Description
4. Schematic Circuit Designation
5. Keithley Part Number

c. All parts listed are maintained in Keithley Spare Parts Stock. Any part not listed can be made available upon request. Parts identified by the Keithley Manufacturing Code Number 80164 should be ordered directly from Keithley Instruments, Inc.

TABLE 6-2.
Schematic Diagrams

Description	Circuit Designation	No.
Power Supply (100 Series)	PC-161	21782D
Lamp Driver (200 Series)	PC-162	21783D
Output Converter (300 Series)	PC-163	21784E
Misc. Gates (400 Series)	PC-165	21785E
Bidirectional Counter (500 Series)	PC-166	21786E
Level Sensors (600 Series)	PC-167	21787E
Integrator (700 Series)	PC-168	21788E
Main Chassis (800 Series)	-	21789E
Model 4190 (900 Series)	PC-174, PC-175	21790E
BCD Converter (1000 Series)	PC-173	21791D
Model 4192 Output Converter (1100 Series)	-	21792D

MAIN CHASSIS PARTS LIST (800 Series)
(Schematic Diagram 21789E)

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
C801	500 µF	35V	EMC	53021	505-2603-01	C20-500/500M	18
C802	500 µF	35V	EMC	53021	505-2603-01	(See C801)	18
C803	500 µF	35V	EMC	53021	505-2603-01	C20-500/500M	18
C804	500 µF	35V	EMC	53021	505-2603-01	(See C803)	18
C805	.02 µF	1000V	CerD	56289	10SS-S20	C22-.02M	19
C806	2.2 µF	20V	ETT	05397	K2R2J20K	C80-2.2M	22
C807	22 µF	20V	ETT	05397	K22J20K	C80-22M	22
C808	.0047 µF	1000V	CerD	56289	10SS-S20	C22-.0047M	22

DIODES

Circuit Desig.	Type	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
D801	Silicon (Metal Can)	1N1563A	04713	RF-19	19
D802	Silicon (Metal Can)	1N1563A	04713	RF-19	19
D803	Silicon	1N3253	02735	RF-20	19
D804	Silicon	1N3253	02735	RF-20	19

LAMPS

Circuit Desig.	Description	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
DS801	10^{-7}A range light	08806	330	PL-39	2
DS802	10^{-6}A range light	08806	330	PL-39	2
DS803	10^{-5}A range light	08806	330	PL-39	2
DS804	10^{-4}A range light	08806	330	PL-39	2
DS805	10^{-3}A range light	08806	330	PL-39	2
DS806	10^{-2}A range light	08806	330	PL-39	2
DS807	10^{-13}A range light	08806	330	PL-39	2
DS808	10^{-12}A range light	08806	330	PL-39	2
DS809	10^{-11}A range light	08806	330	PL-39	2
DS810	10^{-10}A range light	08806	330	PL-39	2
DS811	10^{-9}A range light	08806	330	PL-39	2
DS812	10^{-8}A range light	08806	330	PL-39	2
DS813	- Polarity Light	08806	330	PL-39	2
DS814	+ Polarity Light	08806	330	PL-39	2
DS815	Remote Polarity Light	08806	330	PL-39	2
DS816	Remote Range Light	08806	330	PL-39	2
DS817	Local Range Light	08806	330	PL-39	2
DS818	Auto Range Light	08806	330	PL-39	2
DS819	Zero Check Light	08806	330	PL-39	2
DS820	Meter Expand Light	08806	330	PL-39	2
DS821	Meter On/Off Light	08806	330	PL-39	2
DS822	Power On/Off Light	08806	330	PL-39	2

MISCELLANEOUS PARTS

Circuit Desig.	Description	Mfg. Code	Keithley Part No.	Fig. Ref.
F801 (117 Hz)	Fuse, slow blow, .75A, 250V (Mfg. Type MDL)	71400	FU-19	3
F802 (234 Hz)	Fuse, slow blow, .375A, 250V (Mfg. Type MDL)	71400	FU-18	3
J801	Receptacle, 4190 Input Head	80164	17472A	3
J802	Receptacle, REMOTE HEAD, 15 pins (Mfg. No. DA-15S)	71468	CS-86	3
J803	Receptacle, PRINTER, 15 pins (Mfg. No. DA-15S)	71468	CS-86	3
---	(F)Plug, 15 pins, Mates with J802, J803, J804 (Mfg. No. DA-15P)	71468	CS-87	
---	Dust caps for J802, J803, J804 (Mfg. No. DA-59-20)	71468	CAP-11	
J804	Receptacle, REMOTE CONTROL, 15 pins (Mfg. No. DA-15S)	71468	CS-86	3
J805	Receptacle, Microphone, OUTPUT (Mfg. No. 80PC2F)	02660	CS-32	3
---	(F)Plug, Microphone, Mate of J805 (MFg. No. 80MC2M)	02660	CS-33	
J806	Receptacle, 22 pins, Integrator P.C. Board (Mfg. No. PSC 4SS22-12)	03612	CS-182	
J807	Receptacle, 22 pins, Level Sensors P.C. Board (Mfg. No. PSC 4SS22-12)	03612	CS-182	
J808	Receptacle, 22 pins, Bi-directional Counter P.C. Board (Mfg. No. PSC 4SS22-12)	03612	CS-182	
J809	Receptacle, 44 pins, Misc. Gates P.C. Board (Mfg. No. PSC 4DD22-12)	03612	CS-205	
J810	Receptacle, 22 pins, Output Converter P.C. Board (Mfg. No. PSC 4SS22-12)	03612	CS-182	
J811	Receptacle, 22 pins, Lamp Driver P.C. Board (Mfg. No. PSC 4SS22-12)	03612	CS-182	
J812	Receptacle, 22 pins, Power Supply P.C. Board (Mfg. No. PSC 4SS22-12)	03612	CS-182	
M801	Meter	80164	ME-46	2
P801	Cord Set, 6 feet (Mfg. No. 4638-13)	93656	CO-5	3
S801	Slide Switch, 117-234V	80164	SW-151	3
S802	Rotary Switch less components, RANGE RATE	80164	SW-221	2
---	Rotary Switch with components, Range Rate	80164		
---	Knob, Range Rate	80164	21384A	
S803	Pushbutton Switch Assembly, 16 stations, includes S803, S808 and S809	80164	SW-216	2
S804	Pushbutton Switch Assembly, 8 stations, includes S804, S805, S806 and S807	80164	SW-210	2

(F) Furnished Accessory.

MISCELLANEOUS PARTS (Cont'd.)

Circuit Desig.	Description	Mfg. Code	Keithley Part No.	Fig. Ref.
S805	Range Mode Selection Switch (Part of S804)	--	--	2
S806	Zero Check Switch (Part of S804)	--	--	2
S807	Meter Expand Switch (Part of S804)	--	--	2
S808	Meter On/Off Switch (Part of S803)	--	--	2
S809	Power On/Off Switch (Part of S803)	--	--	2
---	Knob, Damping Control	80164	21384A	2
---	Knob, Zero Control	80164	21333A	2
T801	Transformer	80164	TR-111	18

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
R801	1 Ω	5%, 5 W	WW	91637	RS-5	R4A-1	19
R802	1 Ω	5%, 5 W	WW	91637	RS-5	R4A-1	19
R803	10 Ω	10%, 1/4 W	Comp	44655	RC07	R76-10	--
R804	301 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-301K	22
R805	90.9 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-90.9K	22
R806	249 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-249K	22
R807	200 Ω	5%, 2 W	WWVar	12697	62	RP62-200	--
R808	20 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-20K	22
R809	10 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-10K	22
R810	1.8 kΩ	10%, 1/2 W	Comp	01121	EB	R1-1.8K	22
R811	1 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-1K	--
R812	10 Ω	10%, 1/4 W	Comp	44655	RC07	R76-10	--
R813	10 Ω	10%, 1/4 W	Comp	44655	RC07	R76-10	--
R814	10 Ω	10%, 1/4 W	Comp	44655	RC07	R76-10	--
R815	10 Ω	10%, 1/4 W	Comp	44655	RC07	R76-10	--
R816	10 Ω	10%, 1/4 W	Comp	44655	RC07	R76-10	--
R817	10 Ω	10%, 1/4 W	Comp	44655	RC07	R76-10	--
R818	10 Ω	10%, 1/4 W	Comp	44655	RC07	R76-10	--
R819	10 Ω	10%, 1/4 W	Comp	44655	RC07	R76-10	--
R820	3 kΩ	30%, 1/2 W	CbVar	71450	VF45	RP61-3K	--

TRANSISTORS

Circuit Desig.	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
Q801	2N1535	04713	TG-7	18
Q802	2N1535	04713	TG-7	18

POWER SUPPLY, PC-161 (100 Series)
(Schematic Diagram 21782D)

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
C101	6.4 µF	25V	EAl	73445	C426AR/F6.4	C161-6.4M	34
C102	64 µF	64V	EAl	73445	C437AR/H64	C162-64M	34
C103	680 pF	600V	CerD	72982	ED-680	C22-680P	34
C104	0.1 µF	200V	My	13050	SM1A	C14-.1M	34
C105	100 µF	25V	EAl	56289	89D226	C94-100M	34
C106	1000 µF	25V	EMC	73445	2222-023-90009	C160-1000M	34
C107	0.1 µF	200V	My	13050	SM1A	C143-.1M	34
C108	1000 µF	25V	EMC	73445	2222-023-90009	C160-1000M	34

POWER SUPPLY (Cont'd.)

DIODES

Circuit Desig.	Type	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
D101	Silicon	1N645	01295	RF-14	34
D102	Silicon	1N645	01295	RF-14	34
D103	Silicon	1N645	01295	RF-14	34
D104	Zener	1N715	12954	DZ-22	34
D105	Silicon	1N645	01295	RF-14	34
D106	Silicon	1N645	01295	RF-14	34
D107	Silicon	1N645	01295	RF-14	34
D108	Zener	1N936	04713	DZ-5	34

CONNECTORS

Circuit Desig.	Description	Mfg. Code	Keithley Part No.	Fig. Ref.
J101	Test Jack, Green (Mfg. No. 430-104)	83330	TJ7-G	34
J102	Test Jack, Black (Mfg. No. 430-103)	83330	TJ7-B	34
J103	Test Jack, Red (Mfg. No. 430-102)	83330	TJ7-R	34

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Ref.
R101	550 Ω	1%, 1/2 W	WW	01686	E-30	R58-550	34
R102	1 Ω	1%, 1/2 W	DCb	91637	DCF-1/2	R12-1	34
R103	470 Ω	1%, 1/2 W	WW	01686	E-30	R58-470	34
R104	10 kΩ	10%, 1/2 W	Comp	01121	EB	R1-10K	34
R105	5 kΩ	5%, 5W	WW	94310	5-AL-5	R4A-5K	34
R106	0.1 Ω	1%, 1/2 W	WW	01686	E-30	R58-.1	34
R107	10 kΩ	10%, 1/2 W	Comp	01121	EB	R1-10K	34
R108	820 Ω	10%, 1/2 W	Comp	01121	EB	R1-820	34
R109	820 Ω	10%, 1/2 W	Comp	01121	EB	R1-820	34
R110	22 kΩ	10%, 1/2 W	Comp	01121	EB	R1-22K	34
R111	1.2 kΩ	10%, 1/2 W	Comp	01121	EB	R1-1.2K	34
R112	10 kΩ	10%, 1/2 W	Comp	01121	EB	R1-10K	34
R113	1 kΩ	10%, 1/2 W	Comp	01121	EB	R1-1K	34
R114	3.9 kΩ	10%, 1/2 W	Comp	01121	EB	R1-3.9K	34
R115	604 Ω	1%, 1/2 W	MtF	07716	CEC	R94-604	34
R116	909 Ω	1%, 1/2 W	MtF	07716	CEC	R94-909	34
R117	845 Ω	1%, 1/2 W	MtF	07716	CEC	R94-845	34
R118	3.9 kΩ	10%, 1/2 W	Comp	01121	EB	R1-3.9K	34
R119	3.9 kΩ	10%, 1/2 W	Comp	01121	EB	R1-3.9K	34
R120	3.9 kΩ	10%, 1/2 W	Comp	01121	EB	R1-3.9K	34
R121	499 Ω	1%, 1/2 W	MtF	07716	CEC	R94-499	34
R122	1 kΩ	10%, 1/2 W	WWVar	80294	3067P-1-102	RP39-1K	34
R123	806 Ω	1%, 1/2 W	MtF	07716	CEC	R94-806	34
R124	10 kΩ	10%, 1/2 W	Comp	01121	EB	R1-10K	34
R125	1.5 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-1.5K	34
R126	1.5 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-1.5K	34

TRANSISTORS

Circuit Desig.	Mfr. Desig.	Mfr. Code	Keithley Part No.	Fig. Ref.
Q101	S17638	07263	TG-33*	34
Q102	2N1183	02735	TG-11	34
Q103	S17638	07263	TG-33*	34
Q104	2N1183	02735	TG-11	34
Q105	S17638	07263	TG-33*	34
Q106	S17638	07263	TG-33*	34
Q107	S17638	07263	TG-33*	34
Q108	S17638	07263	TG-33*	34
Q109	S17638	07263	TG-33*	34
Q110	S17638	07263	TG-33*	34

*Selected, order by part no. 21675A.

LAMP DRIVER, PC-162 (200 Series)
(Schematic Diagram 21783D)

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
C201	.001 µF	600V	CerD	72982	ED-.001	C22-.001M	35
C202	100 pF	600V	CerD	72982	ED-100	C22-100P	35
C203	100 pF	600V	CerD	72982	ED-100	C22-100P	35
C204	.001 µF	600V	CerD	72982	ED-.001	C22-.001M	35
C205	100 pF	600V	CerD	72982	ED-100	C22-100P	35
C206	100 pF	600V	CerD	72982	ED-100	C22-100P	35

DIODES

Circuit Desig.	Type	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
D201	Silicon	1N645	01295	RF-14	35
D202	Silicon	1N645	01295	RF-14	35
D203	Silicon	1N645	01295	RF-14	35
D204	Silicon	1N645	01295	RF-14	35
D205	Silicon	1N645	01295	RF-14	35
D206	Silicon	1N645	01295	RF-14	35
D207	Silicon	1N645	01295	RF-14	35
D208	Silicon	1N645	01295	RF-14	35
D209	Silicon	1N645	01295	RF-14	35
D210	Silicon	1N645	01295	RF-14	35
D211	Silicon	1N645	01295	RF-14	35
D212	Silicon	1N645	01295	RF-14	35
D213	Silicon	1N645	01295	RF-14	35
D214	Silicon	1N645	01295	RF-14	35
D215	Silicon	1N645	01295	RF-14	35
D216	Silicon	1N645	01295	RF-14	35
D217	Silicon	1N645	01295	RF-14	35
D218	Silicon	1N645	01295	RF-14	35
D219	Silicon	1N645	01295	RF-14	35
D220	Silicon	1N645	01295	RF-14	35
D221	Silicon	1N645	01295	RF-14	35
D222	Silicon	1N645	01295	RF-14	35
D223	Silicon	1N645	01295	RF-14	35
D224	Silicon	1N645	01295	RF-14	35
D225	Silicon	1N645	01295	RF-14	35

CONNECTORS

Circuit Desig.	Description	Mfg. Code	Keithley Part No.	Fig. Ref.
J201	Test Jack, Red (Mfg. No. 430-102)	83330	TJ7-R	35

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
R201	12 kΩ	10%, 1/4 W	Comp	01121	CB	R76-12K	35
R202	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	35
R203	10 kΩ	10%, 1/4 W	Comp	01121	CB	R76-10K	35
R204	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	35
R205	8.2 kΩ	10%, 1/4 W	Comp	01121	CB	R76-8.2K	35
R206	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	35
R207	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	35
R208	8.2 kΩ	10%, 1/4 W	Comp	01121	CB	R76-8.2K	35
R209	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	35
R210	8.2 kΩ	10%, 1/4 W	Comp	01121	CB	R76-8.2K	35
R211	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	35
R212	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	35

LAMP DRIVER (Cont'd.)

RESISTORS (Cont'd.)

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
R213	8.2 kΩ	10%, 1/4 W	Comp	01121	CB	R76-8.2K	35
R214	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	35
R215	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	35
R216	330 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-330K	35
R217	68 kΩ	10%, 1/4 W	Comp	01121	CB	R76-68K	35
R218	68 kΩ	10%, 1/4 W	Comp	01121	CB	R76-68K	35
R219	68 kΩ	10%, 1/4 W	Comp	01121	CB	R76-68K	35
R220	68 kΩ	10%, 1/4 W	Comp	01121	CB	R76-68K	35
R221	15 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-15K	35
R222	15 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-15K	35
R223	15 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-15K	35
R224	15 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-15K	35
R225	3.3 kΩ	10%, 1/4 W	Comp	01121	CB	R76-3.3K	35
R226	3.3 kΩ	10%, 1/4 W	Comp	01121	CB	R76-3.3K	35
R227	3.3 kΩ	10%, 1/4 W	Comp	01121	CB	R76-3.3K	35
R228	3.3 kΩ	10%, 1/4 W	Comp	01121	CB	R76-3.3K	35
R229	3.3 kΩ	10%, 1/4 W	Comp	01121	CB	R76-3.3K	35
R230	3.3 kΩ	10%, 1/4 W	Comp	01121	CB	R76-3.3K	35
R231	3.3 kΩ	10%, 1/4 W	Comp	01121	CB	R76-3.3K	35
R232	1.8 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.8K	35

TRANSISTORS

Circuit Desig.	Mfr. Desig.	Mfr. Code	Keithley Part No.	Fig. Ref.
Q201	S17638	07263	TG-33*	35
Q202	S17638	07263	TG-33*	35
Q203	S17638	07263	TG-33*	35
Q204	S17638	07263	TG-33*	35
Q205	S17638	07263	TG-33*	35
Q206	S17638	07263	TG-33*	35
Q207	S17638	07263	TG-33*	35
Q208	S17638	07263	TG-33*	35
Q209	S17638	07263	TG-33*	35
Q210	S17638	07263	TG-33*	35
Q211	S17638	07263	TG-33*	35
Q212	S17638	07263	TG-33*	35
Q213	S17638	07263	TG-33*	35
Q214	S17638	07263	TG-33*	35
Q215	S17638	07263	TG-33*	35
Q216	S17638	07263	TG-33*	35
Q217	S17638	07263	TG-33*	35
Q218	S17638	07263	TG-33*	35
Q219	S17638	07263	TG-33*	35
Q220	S17638	07263	TG-33*	35
Q221	S17638	07263	TG-33*	35
Q222	S17638	07263	TG-33*	35
Q223	S17638	07263	TG-33*	35
Q224	S17638	07263	TG-33*	35
Q225	S17638	07263	TG-33*	35

*Selected, order by part no. 21675A.

1248 OUTPUT CONVERTER, PC-163 (300 Series)
(Schematic Diagram 21784E)

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
C301	.001 µF	600V	CerD	72982	ED-.001	C22-.001M	36
C302	.01 µF	600V	CerD	72982	ED-.01	C22-.01M	36
C303	.01 µF	600V	CerD	72982	ED-.01	C22-.01M	36
C304	.001 µF	600V	CerD	72982	ED-.001	C22-.001M	36
C305	.047 µF	200V	My	13050	SM1A	C143-.047M	36
C306	100 pF	600V	CerD	72982	ED-100	C22-100P	36

DIODES

Circuit Desig.	Type	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
D301	Silicon	1N645	01295	RF-14	36
D302	Silicon	1N645	01295	RF-14	36
D303	Silicon	1N645	01295	RF-14	36
D304	Silicon	1N645	01295	RF-14	36
D305	Silicon	1N645	01295	RF-14	36
D306	Silicon	1N645	01295	RF-14	36
D307	Zener	1N718	12954	DZ-18	36

CONNECTORS

Circuit Desig.	Description	Mfg. Code	Keithley Part No.	Fig. Ref.
J301	Test Jack, Red (Mfg. No. 430-102)	83330	TJ7-R	36

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
R301	22 kΩ	10%, 1/4 W	Comp	01121	CB	R76-22K	36
R302	22 kΩ	10%, 1/4 W	Comp	01121	CB	R76-22K	36
R303	22 kΩ	10%, 1/4 W	Comp	01121	CB	R76-22K	36
R304	22 kΩ	10%, 1/4 W	Comp	01121	CB	R76-22K	36
R305	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	36
R306	27 kΩ	10%, 1/4 W	Comp	01121	CB	R76-27K	36
R307	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	36
R308	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	36
R309	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	36
R310	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	36
R311	3.3 kΩ	10%, 1/4 W	Comp	01121	CB	R76-3.3K	36
R312	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	36
R313	22 kΩ	10%, 1/4 W	Comp	01121	CB	R76-22K	36
R314	22 kΩ	10%, 1/4 W	Comp	01121	CB	R76-22K	36
R315	120 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-120K	36
R316	22 kΩ	10%, 1/4 W	Comp	01121	CB	R76-22K	36
R317	22 kΩ	10%, 1/4 W	Comp	01121	CB	R76-22K	36
R318	4.7 kΩ	10%, 1/4 W	Comp	01121	CB	R76-4.7K	36
R319	27 kΩ	10%, 1/4 W	Comp	01121	CB	R76-27K	36
R320	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	36
R321	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	36
R322	27 kΩ	10%, 1/4 W	Comp	01121	CB	R76-27K	36
R323	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	36
R324	150 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-150K	36
R325	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	36

1248 OUTPUT CONVERTER (Cont'd.)

RESISTORS (Cont'd.)

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
R326	27 kΩ	10%, 1/4 W	Comp	01121	CB	R76-27K	36
R327	3.3 kΩ	10%, 1/4 W	Comp	01121	CB	R76-3.3K	36
R328	27 kΩ	10%, 1/4 W	Comp	01121	CB	R76-27K	36
R329	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	36
R330	150 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-150K	36
R331	27 kΩ	10%, 1/4 W	Comp	01121	CB	R76-27K	36
R332	27 kΩ	10%, 1/4 W	Comp	01121	CB	R76-27K	36
R333	3.3 kΩ	10%, 1/4 W	Comp	01121	CB	R76-3.3K	36
R334	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	36
R335	27 kΩ	10%, 1/4 W	Comp	01121	CB	R76-27K	36
R336	27 kΩ	10%, 1/4 W	Comp	01121	CB	R76-27K	36
R337	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	36
R338	3.3 kΩ	10%, 1/4 W	Comp	01121	CB	R76-3.3K	36
R339	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	36
R340	2.2 kΩ	10%, 1/4 W	Comp	01121	CB	R76-2.2K	36
R341	33 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-33K	36
R342	33 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-33K	36
R343	2.2 kΩ	10%, 1/4 W	Comp	01121	CB	R76-2.2K	36
R344	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	36
R345	20 kΩ	10%, 1/2 W	WWVar	80294	3067P-1-203	RP39-20K	36
R346	4.7 kΩ	10%, 1/4 W	Comp	01121	CB	R76-4.7K	36
R347	47 Ω	10%, 1/4 W	Comp	01121	CB	R76-47	36
R348	1 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1K	36
R349	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	36
R350	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	36
R351	27 kΩ	10%, 1/4 W	Comp	01121	CB	R76-27K	36
R352	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	36
R353	3.3 kΩ	10%, 1/4 W	Comp	01121	CB	R76-3.3K	36

TRANSISTORS

Circuit Desig.	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
Q301	S17638	07263	TG-33	36
Q302	S17638	07263	TG-33	36
Q303	S17638	07263	TG-33	36
Q304	S17638	07263	TG-33	36
Q305	2N3565	07263	TG-39	36
Q306	S17638	07263	TG-33	36
Q307	S17638	07263	TG-33	36
Q308	S17638	07263	TG-33	36
Q309	S17638	07263	TG-33	36
Q310	S17638	07263	TG-33	36
Q311	2N3565	07263	TG-39	36
Q312	2N3565	07263	TG-39	36
Q313	2N2646	03508	TG-52	36
Q314	S17638	07263	TG-33	36
Q315	S17638	07263	TG-33	36
Q316	2N3565	07263	TG-39	36
Q317	2N3565	07263	TG-39	36

MISC. GATES, PC-165 (400 Series)
(Schematic Diagram 21785E)

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
C401	100 pF	1000V	CerD	71590	DD-101-10%	C22-100P	37
C402	.001 μF	1000V	CerD	72982	801000X5FO-102K	C22-.001M	37
C403	.0033 μF	1000V	CerD	56289	10SS-D33	C22-.0033M	37

MISC. GATES (Cont'd.)

CAPACITORS (Cont'd.)

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
C404	.0033 µF	600V	CerD	72982	ED-.0033	C22-.0033M	37
C405	.001 µF	600V	CerD	72982	ED-.001	C22-.001M	37
C406	.033 µF	200V	My	13050	SM1A	C143-.033M	37
C407	.001 µF	600V	CerD	72982	ED-.001	C22-.001M	37
C408	1.2 µF	20V	ETT	05397	K1R2J20K	C80-1.2M	37
C409	.0033 µF	600V	CerD	72982	ED-.0033	C22-.0033M	37
C410	.0033 µF	600V	CerD	72982	ED-.0033	C22-.0033M	37
C411	.0033 µF	600V	CerD	72982	ED-.0033	C22-.0033M	37
C412	.001 µF	600V	CerD	72982	ED-.001	C22-.001M	37

DIODES

Circuit Desig.	Type	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
D401	Silicon	1N645	01295	RF-14	37
D402	Silicon	1N645	01295	RF-14	37
D403	Silicon	1N645	01295	RF-14	37
D404	Zener	1N718	12954	DZ-18	37
D405	Silicon	1N645	01295	RF-14	37
D406	Zener	1N718	12954	DZ-18	37
D407	Silicon	1N645	01295	RF-14	37
D408	Zener	1N935	04713	DZ-7	37
D409	Silicon	1N645	01295	RF-14	37
D410	Silicon	1N645	01295	RF-14	37
D411	Zener	1N706	12954	DZ-1	37
D412	Zener	1N718	12954	DZ-18	37
D413	Zener	1N713	12954	DZ-14	37

MISCELLANEOUS PARTS

Circuit Desig.	Description	Mfg. Code	Keithley Part No.	Fig. Ref.
J401	Test Jack, Red (Mfg. No. 430-102)	83330	TJ7-R	37
J402	Test Jack, Green (Mfg. No. 430-104)	83330	TJ7-G	37
K401	Relay (Mfg. No. 226-22P)	82415	RL-29	37
K402	Relay (Mfg. No. 226-22P)	82415	RL-29	37

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
R401	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	37
R402	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	37
R403	10 kΩ	10%, 1/4 W	Comp	01121	CB	R76-10K	37
R404	10 kΩ	10%, 1/4 W	Comp	01121	CB	R76-10K	37
R405	27 kΩ	10%, 1/4 W	Comp	01121	CB	R76-27K	37
R406	27 kΩ	10%, 1/4 W	Comp	01121	CB	R76-27K	37
R407	27 kΩ	10%, 1/4 W	Comp	01121	CB	R76-27K	37
R408	27 kΩ	10%, 1/4 W	Comp	01121	CB	R76-27K	37
R409	27 kΩ	10%, 1/4 W	Comp	01121	CB	R76-27K	37
R410	68 kΩ	10%, 1/4 W	Comp	01121	CB	R76-68K	37
R411	68 kΩ	10%, 1/4 W	Comp	01121	CB	R76-68K	37
R412	68 kΩ	10%, 1/4 W	Comp	01121	CB	R76-68K	37
R413	68 kΩ	10%, 1/4 W	Comp	01121	CB	R76-68K	37
R414	330 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-330K	37
R415	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	37
R416	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	37
R417	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	37
R418	33 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-33K	37
R419	33 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-33K	37
R420	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	37

MISC. GATES (Cont'd.)

RESISTORS (Cont'd.)

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
R421	120 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-120K	37
R422	330 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-330K	37
R423	330 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-330K	37
R424	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	37
R425	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	37
R426	3.3 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-3.3K	37
R427	3.3 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-3.3K	37
R428	68 kΩ	10%, 1/4 W	Comp	01121	CB	R76-68K	37
R429	22 kΩ	10%, 1/4 W	Comp	01121	CB	R76-22K	37
R430	68 kΩ	10%, 1/4 W	Comp	01121	CB	R76-68K	37
R431	10 kΩ	10%, 1/4 W	Comp	01121	CB	R76-10K	37
R432	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	37
R433	10 kΩ	10%, 1/4 W	Comp	01121	CB	R76-10K	37
R434	2.2 kΩ	10%, 1/4 W	Comp	01121	CB	R76-2.2K	37
R435	2.2 kΩ	10%, 1/4 W	Comp	01121	CB	R76-2.2K	37
R436	22 kΩ	10%, 1/4 W	Comp	01121	CB	R76-22K	37
R437	22 kΩ	10%, 1/4 W	Comp	01121	CB	R76-22K	37
R438	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	37
R439	150 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-150K	37
R440	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	37
R441	1.8 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.8K	37
R442	1.8 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.8K	37
R443	1.8 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.8K	37
R444	1.8 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.8K	37
R445	47 Ω	10%, 1/2 W	Comp	01121	EB	R1-47	37
R446	33 Ω	10%, 1/4 W	Comp	01121	CB	R76-33	37
R447	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	37
R448	1 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1K	37
R449	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	37
R450	75 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-75K	37
R451	4.99 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-4.99K	37
R452	1 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1K	37
R453	2.2 kΩ	10%, 1/4 W	Comp	01121	CB	R76-2.2K	37
R454	22 kΩ	10%, 1/4 W	Comp	01121	CB	R76-22K	37
R455	22 kΩ	10%, 1/4 W	Comp	01121	CB	R76-22K	37
R456	2.2 kΩ	10%, 1/4 W	Comp	01121	CB	R76-2.2K	37
R457	Not Used						
R458	10 kΩ	10%, 1/4 W	Comp	01121	CB	R76-10K	37
R459	10 kΩ	10%, 1/4 W	Comp	01121	CB	R76-10K	37
R460	*	1%, 1/8 W	Comp	07716	CEA	R88-*	37
R461	1 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1K	37
R462	47 Ω	10%, 1/4 W	Comp	01121	CB	R76-47	37
R463	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	37
R464	470 kΩ	10%, 1/4 W	Comp	01121	CB	R76-470K	37
R465	15 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-15K	37
R466	100 Ω	10%, 1/4 W	Comp	44655	RC07	R76-100	37
R467	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	37
R468	390 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-390K	37
R469	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	37
R470	*90.9 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-90.9K	37
R471	*100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	37
R472	*50 kΩ	20%, 1/2 W	CbVar	80294	3068P-1-503	RP63-50K	37

*Nominal Value, Selected at factory.

TRANSISTORS

Circuit Desig.	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
Q401	S17638	07263	TG-33	37
Q402	S17638	07263	TG-33	37
Q403	S17638	07263	TG-33	37

* Nominal value, factory set.

MISC. GATES (Cont'd.)

TRANSISTORS (Cont'd.)

Circuit Desig.	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
Q404	S17638	07263	TG-33	37
Q405	S17638	07263	TG-33	37
Q406	S17638	07263	TG-33	37
Q407	S17638	07263	TG-33	37
Q408	S17638	07263	TG-33	37
Q409	S17638	07263	TG-33	37
Q410	S17638	07263	TG-33	37
Q411	S17638	07263	TG-33	37
Q412	S17638	07263	TG-33	37
Q413	S17638	07263	TG-33	37
Q414	S17638	07263	TG-33	37
Q415	S17638	07263	TG-33	37
Q416	2N2646	03508	TG-52	37
Q417	S17638	07263	TG-33	37
Q418	S17638	07263	TG-33	37
Q419	S17638	07263	TG-33	37
Q420	2N2646	03508	TG-52	37
Q421	S17638	07263	TG-33	37
Q422	S17638	07263	TG-33	37
Q423	S17638	07263	TG-33	37

BI-DIRECTIONAL COUNTER, PC-166 (500 Series)
(Schematic Diagram 21786E)

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
C501	1.2 µF	20V	ETT	05397	K1R2J20K	C80-1.2M	38
C502	100 pF	600V	CerD	72982	ED-100	C22-100P	38
C503	100 pF	600V	CerD	72982	ED-100	C22-100P	38
C504	.001 µF	600V	CerD	72982	ED-.001	C22-.001M	38
C505	.001 µF	600V	CerD	72982	ED-.001	C22-.001M	38
C506	1.2 µF	20V	ETT	05397	K1R2J20K	C80-1.2M	38
C507	100 pF	600V	CerD	72982	ED-100	C22-100P	38
C508	100 pF	600V	CerD	72982	ED-100	C22-100P	38
C509	.001 µF	600V	CerD	72982	ED-.001	C22-.001M	38
C510	.001 µF	600V	CerD	72982	ED-.001	C22-.001M	38
C511	100 pF	600V	CerD	72982	ED-100	C22-100P	38
C512	100 pF	600V	CerD	72982	ED-100	C22-100P	38
C513	.0022 µF	600V	CerD	72982	ED-.0022	C22-.0022M	38
C514	.0022 µF	600V	CerD	72982	ED-.0022	C22-.0022M	38
C515	1.2 µF	20V	ETT	05397	K1R2J20K	C80-1.2M	38
C516	100 pF	600V	CerD	72982	ED-100	C22-100P	38
C517	100 pF	600V	CerD	72982	ED-100	C22-100P	38
C518	.001 µF	600V	CerD	72982	ED-.001	C22-.001M	38
C519	.001 µF	600V	CerD	72982	ED-.001	C22-.001M	38
C520	1.2 µF	20V	ETT	05397	K1R2J20K	C80-1.2M	38

DIODES

Circuit Desig.	Type	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
D501	Silicon	1N645	01295	RF-14	38
D502	Silicon	1N645	01295	RF-14	38
D503	Silicon	1N645	01295	RF-14	38
D504	Silicon	1N645	01295	RF-14	38
D505	Silicon	1N645	01295	RF-14	38
D506	Silicon	1N645	01295	RF-14	38
D507	Silicon	1N645	01295	RF-14	38
D508	Silicon	1N645	01295	RF-14	38
D509	Silicon	1N645	01295	RF-14	38
D510	Silicon	1N645	01295	RF-14	38

BIDIRECTIONAL COUNTER (Cont'd.)

DIODES (Cont'd.)

Circuit Desig.	Type	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
D511	Silicon	1N645	01295	RF-14	38
D512	Silicon	1N645	01295	RF-14	38
D513	Silicon	1N645	01295	RF-14	38

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
R501	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	38
R502	6.8 kΩ	10%, 1/4 W	Comp	01121	CB	R76-6.8K	38
R503	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	38
R504	1 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1K	38
R505	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	38
R506	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	38
R507	15 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-15K	38
R508	15 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-15K	38
R509	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	38
R510	12 kΩ	10%, 1/4 W	Comp	01121	CB	R76-12K	38
R511	12 kΩ	10%, 1/4 W	Comp	01121	CB	R76-12K	38
R512	10 kΩ	10%, 1/4 W	Comp	01121	CB	R76-10K	38
R513	12 kΩ	10%, 1/4 W	Comp	01121	CB	R76-12K	38
R514	12 kΩ	10%, 1/4 W	Comp	01121	CB	R76-12K	38
R515	22 kΩ	10%, 1/4 W	Comp	01121	CB	R76-22K	38
R516	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	38
R517	22 kΩ	10%, 1/4 W	Comp	01121	CB	R76-22K	38
R518	15 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-15K	38
R519	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	38
R520	2.7 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-2.7K	38
R521	6.8 kΩ	10%, 1/4 W	Comp	01121	CB	R76-68K	38
R522	12 kΩ	10%, 1/4 W	Comp	01121	CB	R76-12K	38
R523	12 kΩ	10%, 1/4 W	Comp	01121	CB	R76-12K	38
R524	12 kΩ	10%, 1/4 W	Comp	01121	CB	R76-12K	38
R525	12 kΩ	10%, 1/4 W	Comp	01121	CB	R76-12K	38
R526	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	38
R527	15 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-15K	38
R528	15 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-15K	38
R529	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	38
R530	22 kΩ	10%, 1/4 W	Comp	01121	CB	R76-22K	38
R531	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	38
R532	22 kΩ	10%, 1/4 W	Comp	01121	CB	R76-22K	38
R533	2.7 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-2.7K	38
R534	15 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-15K	38
R535	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	38
R536	15 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-15K	38
R537	15 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-15K	38
R538	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	38
R539	12 kΩ	10%, 1/4 W	Comp	01121	CB	R76-12K	38
R540	12 kΩ	10%, 1/4 W	Comp	01121	CB	R76-12K	38
R541	12 kΩ	10%, 1/4 W	Comp	01121	CB	R76-12K	38
R542	12 kΩ	10%, 1/4 W	Comp	01121	CB	R76-12K	38
R543	3.9 kΩ	10%, 1/4 W	Comp	01121	CB	R76-3.9K	38
R544	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	38
R545	15 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-15K	38
R546	2.7 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-2.7K	38
R547	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	38
R548	22 kΩ	10%, 1/4 W	Comp	01121	CB	R76-22K	38
R549	22 kΩ	10%, 1/4 W	Comp	01121	CB	R76-22K	38
R550	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	38
R551	15 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-15K	38
R552	15 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-15K	38
R553	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	38

BIDIRECTIONAL COUNTER (Cont'd.)

RESISTORS (Cont'd.)

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
R554	12 kΩ	10%, 1/4 W	Comp	01121	CB	R76-12K	38
R555	12 kΩ	10%, 1/4 W	Comp	01121	CB	R76-12K	38
R556	12 kΩ	10%, 1/4 W	Comp	01121	CB	R76-12K	38
R557	12 kΩ	10%, 1/4 W	Comp	01121	CB	R76-12K	38
R558	6.8 kΩ	10%, 1/4 W	Comp	01121	CB	R76-6.8K	38
R559	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	38

TRANSISTORS

Circuit Desig.	Mfr. Desig.	Mfr. Code	Keithley Part No.	Fig. Ref.
Q501	S17638	07263	TG-33*	38
Q502	S17638	07263	TG-33*	38
Q503	S17638	07263	TG-33*	38
Q504	S17638	07263	TG-33*	38
Q505	S17638	07263	TG-33*	38
Q506	S17638	07263	TG-33*	38
Q507	S17638	07263	TG-33*	38
Q508	S17638	07263	TG-33*	38
Q509	S17638	07263	TG-33*	38
Q510	S17638	07263	TG-33*	38
Q511	S17638	07263	TG-33*	38
Q512	S17638	07263	TG-33*	38
Q513	S17638	07263	TG-33*	38
Q514	S17638	07263	TG-33*	38
Q515	S17638	07263	TG-33*	38
Q516	S17638	07263	TG-33*	38
Q517	S17638	07263	TG-33*	38

*Selected, order by part no. 21675A

LEVEL SENSORS, PC-167 (600 Series)
(Schematic Diagram 21787E)

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
C601	.1 μF	50V	My	84411	601PE	C41-.1M	39
C602	.02 μF	600V	CerD	72982	ED-.02	C22-.02M	39

DIODES

Circuit Desig.	Type	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
D601	Silicon	1N645	01295	RF-14	39
D602	Silicon	1N645	01295	RF-14	39
D603	Silicon	1N645	01295	RF-14	39
D604	Silicon	1N645	01295	RF-14	39
D605	Silicon	1N645	01295	RF-14	39
D606	Silicon	1N645	01295	RF-14	39
D607	Silicon	1N645	01295	RF-14	39
D608	Silicon	1N645	01295	RF-14	39
D609	Zener	1N718	12954	DZ-18	39
D610	Silicon	1N645	01295	RF-14	39
D611	Silicon	1N645	01295	RF-14	39
D612	Silicon	1N645	01295	RF-14	39

LEVEL SENSORS (Cont'd.)

MISCELLANEOUS PARTS

Circuit Desig.	Description	Mfg. Code	Keithley Part No.	Fig. Ref.
J601	Test Jack, Green (Mfg. No. 430-104)	83330	TJ7-G	39
J602	Test Jack, Red (Mfg. No. 430-102)	83330	TJ7-R	39
K601	Relay (Mfg. No. 226-22P)	82415	RL-29	39

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
R601	3.01 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-3.01K	39
R602	1 MΩ	1%, 1/2 W	MtF	07716	CEC	R94-1M	39
R603	1 MΩ	1%, 1/2 W	MtF	07716	CEC	R94-1M	39
R604	698 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-698K	39
R605	14 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-14K	39
R606	56 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-56K	39
R607	10 kΩ	10%, 1/4 W	Comp	01121	CB	R76-10K	39
R608	2 kΩ	10%, 1/2 W	WWVar	80294	3067P-1-202	RP39-2K	39
R609	2 kΩ	10%, 1/2 W	WWVar	80294	3067P-1-202	RP39-2K	39
R610	50 kΩ	10%, 2 W	WWVar	71450	252	RP37-50K	39
R611	50 kΩ	10%, 2 W	WWVar	71450	252	RP37-50K	39
R612	82 Ω	10%, 1/2 W	Comp	01121	EB	R1-82	39
R613	3.01 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-3.01K	39
R614	162 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-162K	39
R615	5.6 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-5.6K	39
R616	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	39
R617	390 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-390K	39
R618	1 MΩ	1%, 1/2 W	MtF	07716	CEC	R94-1M	39
R619	1 MΩ	1%, 1/2 W	MtF	07716	CEC	R94-1M	39
R620	698 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-698K	39
R621	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	39
R622	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	39
R623	680 kΩ	10%, 1/4 W	Comp	01121	CB	R76-680K	39
R624	10 kΩ	10%, 1/4 W	Comp	01121	CB	R76-10K	39
R625	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	39
R626	470 kΩ	10%, 1/4 W	Comp	01121	CB	R76-470K	39
R627	330 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-330K	39
R628	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	39
R629	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	39
R630	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	39
R631	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	39
R632	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	39
R633	15 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-15K	39
R634	15 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-15K	39
R635	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	39
R636	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	39
R637	15 kΩ	1%, 1/2 W	MtF	07716	CEC	R76-15K	39
R638	560 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-560K	39
R639	560 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-560K	39
R640	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	39
R641	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	39
R642	5.6 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-5.6K	39
R643	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	39
R644	Not used						
R645	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	39
R646	560 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-560K	39
R647	560 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-560K	39
R648	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	39
R649	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	39
R650	560 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-560K	39
R651	15 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-15K	39
R652	15 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-15K	39
R653	15 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-15K	39

LEVEL SENSORS (Cont'd.)

RESISTORS (Cont'd.)

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
R654	10 kΩ	10%, 1/4 W	Comp	01121	CB	R76-10K	39
R655	470 kΩ	10%, 1/4 W	Comp	01121	CB	R76-470K	39
R656	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	39
R657	680 kΩ	10%, 1/4 W	Comp	01121	CB	R76-680K	39
R658	6.8 kΩ	10%, 1/4 W	Comp	01121	CB	R76-6.8K	39
R659	56 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-56K	39
R660	10 kΩ	10%, 1/4 W	Comp	01121	CB	R76-10K	39
R661	6.8 kΩ	10%, 1/4 W	Comp	01121	CB	R76-6.8K	39
R662	560 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-560K	39
R663	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	39
R664	560 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-560K	39
R665	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	39
R666	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	39
R667	47 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-47K	39
R668	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	39

TRANSISTORS

Circuit Desig.	Mfr. Desig.	Mfr. Code	Keithley Part No.	Fig. Ref.
Q601**		80164	19447A	39
Q602		80164	19447A	39
Q603	2N3565	07263	TG-39	39
Q604	2N3565	07263	TG-39	39
Q605	S17638	07263	TG-33*	39
Q606	S17638	07263	TG-33*	39
Q607	S17638	07263	TG-33*	39
Q608	S17638	07263	TG-33*	39
Q609**		80164	19447A	39
Q610**		80164	19447A	39
Q611	2N3565	07263	TG-39	39
Q612	2N3565	07263	TG-39	39
Q613	S17638	07263	TG-33*	39
Q614	S17638	07263	TG-33*	39
Q615	S17638	07263	TG-33*	39
Q616	S17638	07263	TG-33*	39
Q617	S17638	07263	TG-33*	39
Q618	S17638	07263	TG-33*	39
Q619	S17638	07263	TG-33*	39
Q620	S17638	07263	TG-33*	39
Q621	S17638	07263	TG-33*	39
Q622	S17638	07263	TG-33*	39
Q623	S17638	07263	TG-33*	39
Q624	S17638	07263	TG-33*	39
Q625	S17638	07263	TG-33*	39

*Selected, order by part no. 21675A

INTEGRATOR, PC-168 (700 Series)
(Schematic Diagram 21788D)

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
C701	0.1 μF	50V	My	84411	601PE	C41-.1M	40
C702	0.1 μF	100V	My	12673	23M	C105-.1M	40
C703	1.0 μF	200V	My	13050	SM1A	C143-1M	40

** Q601 and Q602 are matched; replace as a pair. Q609 and Q610 are matched; replace as a pair.

INTEGRATOR (Cont'd.)

DIODES

Circuit Desig.	Type	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
D701	Silicon	1N645	01295	RF-14	40
D702	Silicon	1N645	01295	RF-14	40
D703	Silicon	1N645	01295	RF-14	40
D704	Silicon	1N645	01295	RF-14	40
D705	Silicon	1N645	01295	RF-14	40
D706	Silicon	1N645	01295	RF-14	40

MISCELLANEOUS PARTS

Circuit Desig.	Description	Mfg. Code	Keithley Part No.	Fig. Ref.
J701	Test Jack, Green (Mfg. No. 430-104)	83330	TJ7-G	40
J702	Test Jack, Red, (Mfg. No. 430-102)	83330	TJ7-R	40
K701	Relay (Mfg. No. W101MPCX-2)	94696	RL-30	40
K702	Relay (Mfg. No. 226-22P)	82415	RL-29	40
K703	Relay (Mfg. No. 226-22P)	82415	RL-29	40

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
R701(60 Hz)	333 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-333K	40
R701(50 Hz)	402 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-402K	40
R702	13 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-13K	40
R703	39 kΩ	10%, 1/4 W	Comp	01121	CB	R76-39K	40
R704	16.5 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-16.5K	40
R705	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	40
R706	40.2 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-40.2K	40
R707	100 Ω	10%, 1/2 W	Comp	01121	EB	R1-100	40
R708	80.6 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-80.6K	40
R709	82 Ω	10%, 1/2 W	Comp	01121	EB	R1-82	40
R710	80.6 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-80.6K	40
R711	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	40
R712	4.7 kΩ	10%, 1/4 W	Comp	01121	CB	R76-4.7K	40
R713	22 kΩ	10%, 1/4 W	Comp	01121	CB	R76-22K	40
R714	22 kΩ	10%, 1/4 W	Comp	01121	CB	R76-22K	40
R715	500 Ω	10%, 1/2 W	WWVar	80294	3067P-1-501	RP39-500	40
R716	2.21 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-2.21K	40
R717	1 kΩ	10%, 1/2 W	WWVar	80294	3067P-1-102	RP39-1K	40
R718	200 Ω	1%, 1/2 W	MtF	07716	CEC	R94-200	40
R719	499 Ω	1%, 1/2 W	MtF	07716	CEC	R94-750	40
R720	82 Ω	10%, 1/2 W	Comp	01121	EB	R1-82	40
R721	4.02 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-4.02K	40
R722	15 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-15K	40
R723	100 Ω	10%, 1/4 W	Comp	44655	RC07	R76-100	40
R724	2.2 kΩ	10%, 1/4 W	Comp	01121	CB	R76-2.2K	40
R725	330 Ω	10%, 1/4 W	Comp	01121	CB	R76-330K	40
R726	470 kΩ	10%, 1/4 W	Comp	01121	CB	R76-470K	40
R727	150 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-150K	40
R728	33 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-33K	40
R729	33 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-33K	40
R730	470 kΩ	10%, 1/4 W	Comp	01121	CB	R76-470K	40
R731	10 Ω	10%, 1/4 W	Comp	44655	RC07	R76-10	40
R732	22 Ω	10%, 1/4 W	Comp	44655	RC07	R76-22	40

TRANSISTORS

Circuit Desig.	Mfr. Desig.	Mfr. Code	Keithley Part No.	Fig. Ref.
Q701	2N3565	07263	TG-39	40
Q702	S17638	07263	TG-33	40
Q703	SF5043	01295	TG-40	40

INTEGRATOR (Cont'd.)

TRANSISTORS (Cont'd.)

Circuit Desig.	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
Q704	TIS-70→ SF5043 [redacted]	01295	TG-40	40
Q705	2N3565	07263	TG-39	40
Q706	S17638	07263	TG-33*	40
Q707	2N3565	07263	TG-39	40
Q708	S17638	07263	TG-33*	40
Q709	S17638	07263	TG-33*	40
Q710	2N3565	07263	TG-39	40
Q711	S17638	07263	TG-33*	40

*Selected, order by part no. 21675A

MODEL 4190 INPUT HEAD, PC-174, PC-175 (900 Series)
(Schematic Diagram 21790E)

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
C901	5 pF	200V	Poly	14167	E1013-1	C31-5P	41
C902	50 pF	500V	Poly	71590	CPR-50J	C138-50P	41
C903	500 pF	500V	Poly	71590	CPR-500J	C138-500P	41
C904	5000 pF	500V	Poly	71590	CPR-5000J	C138-5000P	41
C905	500 pF	500V	Poly	71590	CPR-500J	C138-500P	41
C906	5000 pF	500V	Poly	71590	CPR-5000J	C138-5000P	41
C907	5000 pF	500V	Poly	71590	CPR-5000J	C138-5000P	41
C908	0.1 µF	200V	My	13050	SM1A	C47-.1M	41
C909	0.01 µF	400V	My	14655	WMF4S1	C114-.01M	41
C910	.001 µF	600V	CerD	72982	ED-.001	C22-.001M	41
C911	2.7 pF	500V	CerT	00656	CC-20	C77-2.7P	41
C912	22 pF	500V	Poly	71590	CPR-22J	C138-22P	41
C913	30 pF	500V	CerT	71590	TCZ	C77-30P	41
C914	330 pF	600V	CerD	72982	ED-330	C22-330P	41
C915	.0022 µF	600V	CerD	72982	ED-.0022	C22-.0022M	41
C916	.0022 µF	600V	CerD	72982	ED-.0022	C22-.0022M	41
C917	.0022 µF	600V	CerD	72982	ED-.0022	C22-.0022M	41
C918	100 pF	600V	CerD	72982	ED-100	C22-100P	41
C919	.25 µF	400V	My	13050	SM1A	C73-.25M	41
C920	.022 µF	400V	My	13050	SM1A	C73-.022M	41
C921	100 µF	25V	ETT	05079	W100-25C2U1	C96-100M	41
C922	*47 pF	600V	CerD	72982	ED-47	C22-47P	41
C923	100 µF	25V	ETT	05079	W100-25C2U1	C96-100M	41
C924	10 µF	20V	ETT	05397	K10J20K	C80-10M	41

DIODES

Circuit Desig.	Type	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
D901	Silicon	2N3565	07263	TG-39	41
D902	Silicon	2N3565	07263	TG-39	41
D903	Zener	1N706	12954	DZ-1	41
D904	Zener	1N706	12954	DZ-1	41
D905	Zener	1N706	12954	DZ-1	41
D906	Silicon	1N645	01295	RF-14	41
D907	Silicon	1N645	01295	RF-14	41
D908	Silicon	1N645	01295	RF-14	41
D909	Silicon	1N645	01295	RF-14	41
D910	Silicon	1N645	01295	RF-14	41
D911	Silicon	1N645	01295	RF-14	41
D912	Silicon	1N645	01295	RF-14	41
D913	Silicon	1N645	01295	RF-14	41

* Nominal value, factory set.

INPUT HEAD (Cont'd.)

DIODES (Cont'd.)

Circuit Desig.	Type	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
D914	Silicon	1N645	01295	RF-14	41
D915	Silicon	1N645	01295	RF-14	41
D916	Silicon	1N645	01295	RF-14	41
D917	Not used				
D918	Silicon	1N645	01295	RF-14	41
D919	Silicon	1N645	01295	RF-14	41
D920	Silicon	1N645	01295	RF-14	41
D921	Silicon	1N645	01295	RF-14	41
D922	Silicon	1N645	01295	RF-14	41

MISCELLANEOUS PARTS

Circuit Desig.	Description	Mfg. Code	Keithley Part No.	Fig. Ref.
21791D	BCD Convertor P.C. Board. Circuit designations are 1000 series: Refer to page 00 for Parts List and to page 00 for Schematic Diagram (Drawing 21791D).	80164		41
J901	Jack, INPUT (Mfg. No. 30116A-NT34)	95712	CS-134	41
J902	Printed Circuit Contacts (Mfg. No. 02-018-6-200)	91662	CS-176	41
K901	Reed Relay, SPST (Mfg. No. MR406)	95348	RL-25B	41
K902	Relay (Mfg. No. 226-22P)	82415	RL-29	41
K903	Reed Relay, SPDT (Gen Reed-C)	80164	22858A	41
K904	Reed Relay, SPDT (Gen Reed-C)	80164	22858A	41
K905	Reed Relay, SPDT (Gen Reed-C)	80164	22858A	41
K906	Reed Relay, SPDT (Gen Reed-C)	80164	22858A	41
K907	Reed Relay, SPDT (Gen Reed-C)	80164	22858A	41
K908	Reed Relay, SPDT (Gen Reed-C)	23020	RL-26	41
K909	Reed Relay, SPDT (Gen Reed-C)	23020	RL-26	41
K910	Reed Relay, SPDT (Gen Reed-C)	23020	RL-26	41
K911	Reed Relay, SPDT (Gen Reed-C)	23020	RL-26	41
K912	Relay (Mfg. No. 226-22P)	82415	RL-29	41
K913	Relay (Mfg. No. 226-22P)	82415	RL-29	41
K914	Relay (Mfg. No. 226-22P)	82415	RL-29	41
K915	Reed Relay, DPDT (Mfg. No. T154-2C)	70309	RL-23	41
P901	Plug (Mfg. No. DA-15P)	71468	CS-87	41

ALL OF THESE USE KEITHLEY PART # 21754

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
R901	33 kΩ	10%, 1/2 W	Comp	01121	EB	R1-33K	41
R902	10^{12} Ω	+3%, -0%	GCb	63060	RX-1	R20-10^{12}	41
R903	2 MΩ	30%, 1/4 W	CompV	71450	UPM-45	RP12-2M	41
R904	68 kΩ	10%, 1/2 W	Comp	01121	EB	R1-68K	41
R905	2 MΩ	30%, 1/4 W	CompV	71450	UPM-45	RP12-2M	41
R906	10^{11} Ω	+3%, -0%	GCb	63060	RX-1	R20-10^{11}	41
R907	10^{10} Ω	+3%, -0%	GCb	63060	RX-1	R20-10^{10}	41
R908	2 MΩ	30%, 1/4 W	CompV	71450	UPM-45	RP12-2M	41
R909	10^{9} Ω	+3%, -0%	GCb	63060	RX-1	R20-10^{9}	41
R910	180 kΩ	10%, 1/2 W	Comp	01121	EB	R1-180K	41
R911	330 kΩ	10%, 1/2 W	Comp	01121	EB	R1-330K	41
R912	2 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-2K	41
R913	10^{8} Ω	1%, 2 W	DCb	91637	DC-2	R14-100M	41
R914	75 Ω	1%, 1/2 W	MtF	07716	CEC	R94-75	41
R915	1 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-1K	41
R916	10^{7} Ω	1%, 1/2 W	DCb	91637	DCF-1/2	R12-10M	41
R917	10^{6} Ω	1%, 1/2 W	DCb	91637	DCF-1/2	R12-1M	41
R918	10^{5} Ω	1%, 1/2 W	DCb	91637	DCF-1/2	R12-100K	41

INPUT HEAD (Cont'd.)

RESISTORS (Cont'd.)

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
R919	333 Ω	1%, 1/2 W	MtF	07716	CEC	R94-333	41
R920	3.33 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-3.33K	41
R921	33.3 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-33.3K	41
R922	10 MΩ	10%, 1/2 W	Comp	01121	EB	R1-10M	41
R923	10 Ω	10%, 1/2 W	Comp	01121	EB	R1-10	41
R924	*33 Ω	10%, 1/2 W	Comp	01121	EB	R1-33	41
R925	200 Ω	1%, 1/2 W	WW	01686	E-30	R58-200	41
R926	1300 Ω	1%, 1/2 W	WW	01686	E-30	R58-1300	41
R927	121 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-121K	41
R928	*1 kΩ	1%, 1/2 W	WW	01686	E-30	R58-1K	41
R929	22 kΩ	10%, 1/2 W	Comp	01121	EB	R1-22K	41
R930	1 kΩ	10%, 1/2 W	WWVar	80294	3067P-1-102	RP39-1K	41
R931	75 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-75K	41
R932	10 kΩ	10%, 1/2 W	Comp	01121	EB	R1-10K	41
R933	47 Ω	10%, 1/2 W	Comp	01121	EB	R1-47	41
R934	*150 Ω	10%, 1/2 W	Comp	01121	EB	R1-150	41
R935	6.8 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-6.8K	41
R936	6.8 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-6.8K	41
R937	75 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-75K	41
R938	6 kΩ	1%, 1/2 W	DCb	91637	DCF-1/2	R12-6K	41
R939	3.4 kΩ	1%, 1/2 W	DCb	91637	DCF-1/2	R12-3.4K	41
R940	4.7 kΩ	10%, 1/2 W	Comp	01121	EB	R1-4.7K	41
R941	1.8 kΩ	10%, 1/2 W	Comp	01121	EB	R1-1.8K	41
R942	22 Ω	10%, 1/2 W	Comp	01121	EB	R1-22	41
R943	560 Ω	10%, 1 W	Comp	01121	GB	R2-560	41
R944	47 Ω	10%, 1/2 W	Comp	01121	EB	R1-47	41
R945	22 MΩ	10%, 1/2 W	Comp	01121	EB	R1-22M	41
R946	120 kΩ	10%, 1/2 W	Comp	01121	EB	R1-120K	41

*Nominal value, selected at factory.

TRANSISTORS

Circuit Desig.	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
Q901	2N3565	07263	TG-39	41
Q902	2N3565	07263	TG-39	41
Q903	2N3565	07263	TG-39	41
Q904	2N3565	07263	TG-39	41
Q905	2N651	04713	TG-9	41
Q906	2N1183	02735	TG-11	41

VACUUM TUBES

Circuit Desig.	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
V901	5886	80164	EV-5886-2X	41

BCD CONVERTER, PC-173 (1000 Series)
(Schematic Diagram 21791D)

DIODES

Circuit Desig.	Type	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
D1001	Silicon	1N645	01295	RF-14	42
D1002	Silicon	1N645	01295	RF-14	42
D1003	Silicon	1N645	01295	RF-14	42
D1004	Silicon	1N645	01295	RF-14	42
D1005	Silicon	1N645	01295	RF-14	42

* Nominal value, factory set.

BCD CONVERTER (Cont'd.)

DIODES (Cont'd.)

Circuit Desig.	Type	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
D1006	Silicon	1N645	01295	RF-14	42
D1007	Silicon	1N645	01295	RF-14	42
D1008	Silicon	1N645	01295	RF-14	42
D1009	Silicon	1N645	01295	RF-14	42
D1010	Silicon	1N645	01295	RF-14	42
D1011	Silicon	1N645	01295	RF-14	42
D1012	Silicon	1N645	01295	RF-14	42
D1013	Silicon	1N645	01295	RF-14	42
D1014	Silicon	1N645	01295	RF-14	42
D1015	Silicon	1N645	01295	RF-14	42
D1016	Silicon	1N645	01295	RF-14	42
D1017	Silicon	1N645	01295	RF-14	42
D1018	Silicon	1N645	01295	RF-14	42
D1019	Silicon	1N645	01295	RF-14	42
D1020	Silicon	1N645	01295	RF-14	42
D1021	Silicon	1N645	01295	RF-14	42
D1022	Silicon	1N645	01295	RF-14	42
D1023	Silicon	1N645	01295	RF-14	42
D1024	Silicon	1N645	01295	RF-14	42
D1025	Silicon	1N645	01295	RF-14	42
D1026	Silicon	1N645	01295	RF-14	42
D1027	Silicon	1N645	01295	RF-14	42

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
R1001	3.3 kΩ	10%, 1/4 W	Comp	01121	CB	R76-3.3K	42
R1002	3.3 kΩ	10%, 1/4 W	Comp	01121	CB	R76-3.3K	42
R1003	3.3 kΩ	10%, 1/4 W	Comp	01121	CB	R76-3.3K	42
R1004	3.3 kΩ	10%, 1/4 W	Comp	01121	CB	R76-3.3K	42
R1005	3.3 kΩ	10%, 1/4 W	Comp	01121	CB	R76-3.3K	42
R1006	3.3 kΩ	10%, 1/4 W	Comp	01121	CB	R76-3.3K	42
R1007	3.3 kΩ	10%, 1/4 W	Comp	01121	CB	R76-3.3K	42
R1008	3.3 kΩ	10%, 1/4 W	Comp	01121	CB	R76-3.3K	42
R1009	15 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-15K	42
R1010	15 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-15K	42
R1011	15 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-15K	42
R1012	15 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-15K	42
R1013	22 Ω	10%, 1/4 W	Comp	44655	RC07	R76-22	42
R1014	22 Ω	10%, 1/4 W	Comp	44655	RC07	R76-22	42
R1015	22 Ω	10%, 1/4 W	Comp	44655	RC07	R76-22	42

TRANSISTORS

Circuit Desig.	Mfr. Desig.	Mfr. Code	Keithley Part No.	Fig. Ref.
Q1001	S17638	07263	TG-33*	42
Q1002	S17638	07263	TG-33*	42
Q1003	S17638	07263	TG-33*	42
Q1004	S17638	07263	TG-33*	42
Q1005	S17638	07263	TG-33*	42
Q1006	S17638	07263	TG-33*	42
Q1007	S17638	07263	TG-33*	42
Q1008	S17638	07263	TG-33*	42
Q1009	S17638	07263	TG-33*	42
Q1010	S17638	07263	TG-33*	42
Q1011	S17638	07263	TG-33*	42
Q1012	S17638	07263	TG-33*	42
Q1013	S17638	07263	TG-33*	42
Q1014	S17638	07263	TG-33*	42
Q1015	S17638	07263	TG-33*	42

*Selected, order by part no. 21675A.

BCD CONVERTER (Cont'd.)

TRANSISTORS (Cont'd.)

Circuit Desig.	Mfr. Desig.	Mfr. Code	Keithley Part No.	Fig. Ref.
Q1016	S17638	07263	TG-33*	42
Q1017	S17638	07263	TG-33*	42
Q1018	S17638	07263	TG-33*	42

OPTIONAL OUTPUT CONVERTER (Model 4192) (1100 Series)
(Schematic Diagram 21792E)

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
C1101	.001 µF	600V	CerD	72982	ED-.001	C22-.001M	43
C1102	.01 µF	600V	CerD	72982	ED-.01	C22-.01M	43
C1103	.01 µF	600V	CerD	72982	ED-.01	C22-.01M	43
C1104	.047 µF	200V	My	13050	SM1A	C143-.047M	43
C1105	.001 µF	600V	CerD	72982	ED-.001	C22-.001M	43
C1106	100 pF	600V	CerD	72982	ED-100	C22-100P	43

CONNECTORS

Circuit Desig.	Description	Mfg. Code	Keithley Part No.	Fig. Ref.
J1101	Test Jack, Red (Mfg. No. 430-102)	83330	TJ7-R	43

DIODES

Circuit Desig.	Type	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
D1101	Silicon	1N645	01295	RF-14	43
D1102	Silicon	1N645	01295	RF-14	43
D1103	Zener	1N718	12954	DZ-18	43

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
R1101	22 kΩ	10%, 1/4 W	Comp	01121	CB	R76-22K	43
R1102	1.5 kΩ	10%, 1/4 W	Comp	01121	CB	R76-1.5K	43
R1103	33 kΩ	10%, 1/4 W	Comp	01121	CB	R76-33K	43
R1104	47 kΩ	10%, 1/4 W	Comp	01121	CB	R76-47K	43
R1105	10 kΩ	10%, 1/4 W	Comp	01121	CB	R76-10K	43
R1106	22 kΩ	10%, 1/4 W	Comp	01121	CB	R76-22K	43
R1107	150 kΩ	10%, 1/4 W	Comp	01121	CB	R76-150K	43
R1108	22 kΩ	10%, 1/4 W	Comp	01121	CB	R76-22K	43
R1109	22 kΩ	10%, 1/4 W	Comp	01121	CB	R76-22K	43
R1110	1.2 kΩ	10%, 1/4 W	Comp	01121	CB	R76-1.2K	43
R1111	330 kΩ	10%, 1/4 W	Comp	01121	CB	R76-330K	43
R1112	47 kΩ	10%, 1/4 W	Comp	01121	CB	R76-47K	43
R1113	47 kΩ	10%, 1/4 W	Comp	01121	CB	R76-47K	43
R1114	3.3 kΩ	10%, 1/4 W	Comp	01121	CB	R76-3.3K	43
R1115	330 kΩ	10%, 1/4 W	Comp	01121	CB	R76-330K	43
R1116	47 kΩ	10%, 1/4 W	Comp	01121	CB	R76-47K	43
R1117	22 kΩ	10%, 1/4 W	Comp	01121	CB	R76-22K	43
R1118	47 kΩ	10%, 1/4 W	Comp	01121	CB	R76-47K	43
R1119	1.2 kΩ	10%, 1/4 W	Comp	01121	CB	R76-1.2K	43
R1120	1.5 kΩ	10%, 1/4 W	Comp	01121	CB	R76-1.5K	43
R1121	47 kΩ	10%, 1/4 W	Comp	01121	CB	R76-47K	43
R1122	47 kΩ	10%, 1/4 W	Comp	01121	CB	R76-47K	43
R1123	10 kΩ	10%, 1/4 W	Comp	01121	CB	R76-10K	43
R1124	330 kΩ	10%, 1/4 W	Comp	01121	CB	R76-330K	43
R1125	1.5 kΩ	10%, 1/4 W	Comp	01121	CB	R76-1.5K	43

OUTPUT CONVERTER (Cont'd.)

RESISTORS (Cont'd.)

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
R1126	33 kΩ	10%, 1/4 W	Comp	01121	CB	R76-33K	43
R1127	47 kΩ	10%, 1/4 W	Comp	01121	CB	R76-47K	43
R1128	3.3 kΩ	10%, 1/4 W	Comp	01121	CB	R76-3.3K	43
R1129	47 kΩ	10%, 1/4 W	Comp	01121	CB	R76-47K	43
R1130	330 kΩ	10%, 1/4 W	Comp	01121	CB	R76-330K	43
R1131	47 kΩ	10%, 1/4 W	Comp	01121	CB	R76-47K	43
R1132	33 kΩ	10%, 1/4 W	Comp	01121	CB	R76-33K	43
R1133	47 kΩ	10%, 1/4 W	Comp	01121	CB	R76-47K	43
R1134	3.3 kΩ	10%, 1/4 W	Comp	01121	CB	R76-3.3K	43
R1135	10 kΩ	10%, 1/4 W	Comp	01121	CB	R76-10K	43
R1136	33 kΩ	10%, 1/4 W	Comp	01121	CB	R76-33K	43
R1137	47 kΩ	10%, 1/4 W	Comp	01121	CB	R76-47K	43
R1138	3.3 kΩ	10%, 1/4 W	Comp	01121	CB	R76-3.3K	43
R1139	22 kΩ	10%, 1/4 W	Comp	01121	CB	R76-22K	43
R1140	100 kΩ	10%, 1/4 W	Comp	01121	CB	R76-100K	43
R1141	2.2 kΩ	10%, 1/4 W	Comp	01121	CB	R76-2.2K	43
R1142	33 kΩ	10%, 1/4 W	Comp	01121	CB	R76-33K	43
R1143	33 kΩ	10%, 1/4 W	Comp	01121	CB	R76-33K	43
R1144	2.2 kΩ	10%, 1/4 W	Comp	01121	CB	R76-2.2K	43
R1145	100 kΩ	10%, 1/4 W	Comp	01121	CB	R76-100K	43
R1146	20 kΩ	10%, 1/2 W	WWVar	80294	3067P-1-203	RP39-20K	43
R1147	4.7 kΩ	10%, 1/4 W	Comp	01121	CB	R76-4.7K	43
R1148	1 kΩ	10%, 1/4 W	Comp	01121	CB	R76-1K	43
R1149	47 Ω	10%, 1/4 W	Comp	01121	CB	R76-47	43
R1150	100 kΩ	10%, 1/4 W	Comp	01121	CB	R76-100K	43
R1151	47 kΩ	10%, 1/4 W	Comp	01121	CB	R76-47K	43
R1152	33 kΩ	10%, 1/4 W	Comp	01121	CB	R76-33K	43
R1153	47 kΩ	10%, 1/4 W	Comp	01121	CB	R76-47K	43
R1154	3.3 kΩ	10%, 1/4 W	Comp	01121	CB	R76-3.3K	43

TRANSISTORS

Circuit Desig.	Mfr. Desig.	Mfr. Code	Keithley Part No.	Fig. Ref.
Q1101	S17638	07263	TG-33*	43
Q1102	2N3565	07263	TG-39	43
Q1103	S17638	07263	TG-33*	43
Q1104	S17638	07263	TG-33*	43
Q1105	S17638	07263	TG-33*	43
Q1106	S17638	07263	TG-33*	43
Q1107	S17638	07263	TG-33*	43
Q1108	S17638	07263	TG-33*	43
Q1109	2N3565	07263	TG-39*	43
Q1110	2N3565	07263	TG-39*	43
Q1111	S17638	07263	TG-33*	43
Q1112	2N3565	07263	TG-39	43
Q1113	S17638	07263	TG-33*	43
Q1114	S17638	07263	TG-33*	43
Q1115	S17638	07263	TG-33*	43
Q1116	2N2646	03508	TG-52	43
Q1117	S17638	07263	TG-33*	43
Q1118	2N3565	07263	TG-39	43

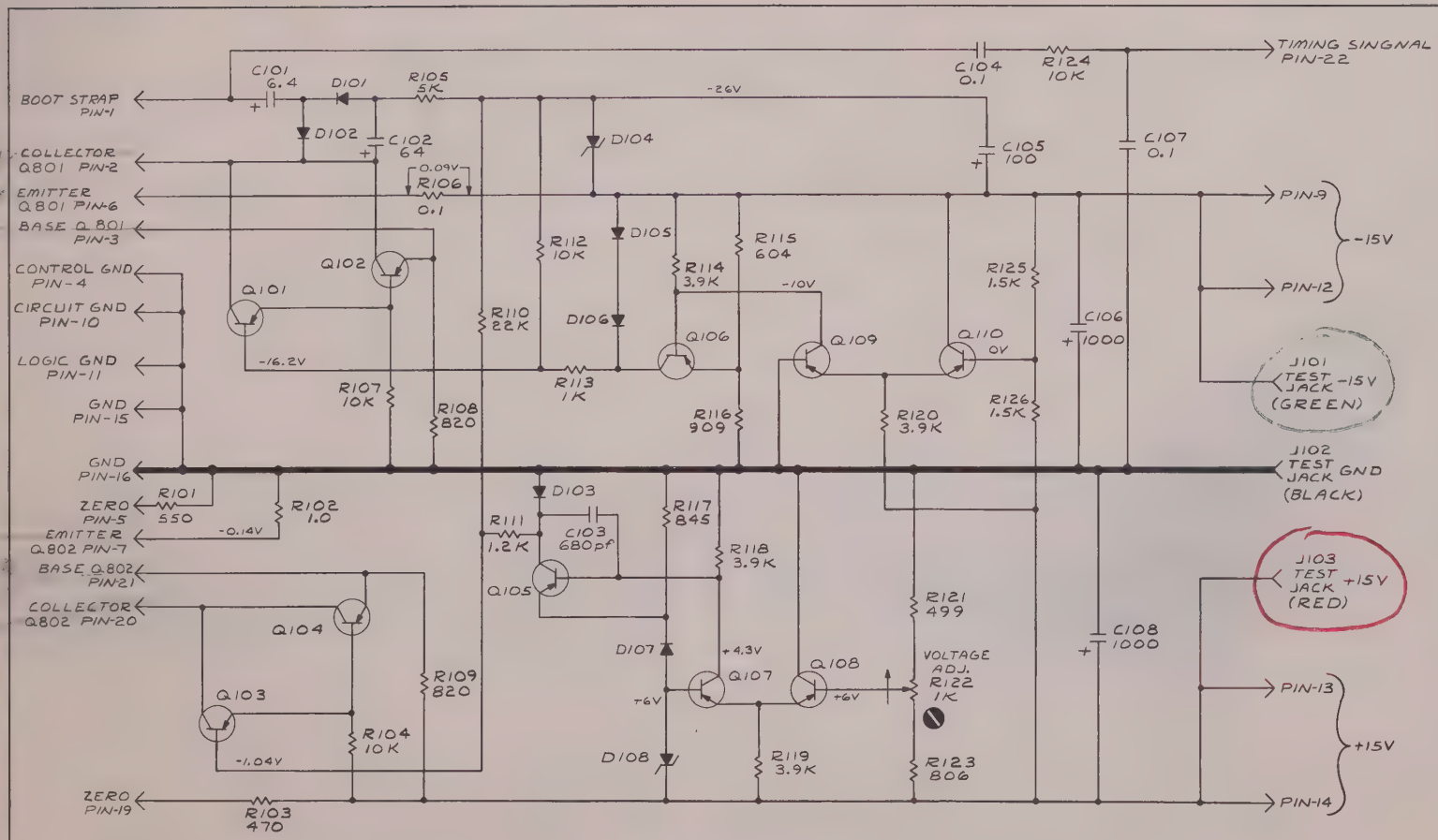
*Selected, order by part no. 21675A.

TABLE 6-3.
Code-to-Name List

00656	Aerovox Corp. 740 Belleville Avenue New Bedford, Mass. 02741
01121	Allen-Bradley Corp. 1201 South 2nd Street Milwaukee, Wis. 53204
01295	Texas Instruments, Inc. Semiconductor-Components Division 13500 North Central Expwy. Dallas, Texas 75231
01686	RCL Electronics, Inc. 195 McGregor Street Manchester, N.H. 03102
02660	Amphenol Corp. 2801 South 25th Avenue Broadview, Ill. 60153
02735	Radio Corp. of America Commercial Receiving Tube & Semiconductor Division Somerville, N.J.
03508	General Electric Company Semiconductor Prod. Dept. Electronics Park Syracuse, New York 13201
04713	Motorola Semiconductor Products Inc. 5005 East McDowell Rd. Phoenix, Arizona 85008
05079	Tansitor Electronics Inc. 1000 West Road Bennington, Vt. 05201
05397	Union Carbide Corp. Linde Div. Kemet Corp. 11901 Madison Ave. Cleveland, Ohio 44107
07263	Fairchild Camera & Instrument Corp. Semiconductor Division 313 Frontage Road Mountain View, Calif.
07716	IRC, Inc. 2850 Mt. Pleasant Burlington, Iowa 52601
08806	General Electric Company Miniature Lamp Dept. Nela Park Cleveland, Ohio 44112
09922	Burndy Corp. Richards Avenue Norwalk, Conn. 06852
12697	Clarostat Mfg. Co., Inc. Lower Washington St. Dover, N.H. 03820
12954	Dickson Electronics Corp. 302 S. Wells Fargo Ave. Scottsdale, Arizona
13050	Potter Co. Highway 51 N. Wesson, Miss. 39191
23020	General Reed Company 174 Main Street Metuchen, New Jersey 08840
44655	Ohmite Mfg. Co. 3601 Howard Street Skokie, Ill. 60076
53021	Sangamo Electric Co. 1301 North 11th Street Springfield, Ill. 62705
63060	Victoreen Instrument Co. 5806 Hough Avenue Cleveland, Ohio 44103
70309	Allied Control Co., Inc. 2 East End Avenue New York, N.Y.
71400	Bussmann Mfg., Div. of McGraw-Edison Co. 2538 W. University St. St. Louis, Mo.
71450	CTS Corp. 1142 W. Beardsley Ave. Elkhart, Ind.
71468	ITT Cannon Electric, Inc. 3208 Humbolt St. Los Angeles, Calif. 90031
71590	Centralab, Division of Globe-Union, Inc. 932 E. Keefe Ave. Milwaukee, Wis. 53212
72982	Erie Technological Products, Inc. 644 W. 12th St. Erie, Pa. 16512
73445	Amperex Electronic Co. Div. of North American Philips Co., Inc. Hicksville, N.Y.
80164	Keithley Instruments, Inc. 28775 Aurora Road Cleveland, Ohio 44139
80294	Bourns, Inc. 6135 Magnolia Drive Riverside, Calif. 92506
82415	Price Electric Corp. 5560 Church Fredrick, Md. 21701
83125	General Instrument Corp. Capacitor Division Orange Street Darlington, S.C. 29532
83330	Smith, Herman H., Inc. 812 Snediker Avenue Brooklyn, N.Y. 11207
84411	TRW Capacitor Division 112 W. First St. Ogallala, Nebr.
91637	Dale Electronics, Inc. P.O. Box 609 Columbus, Nebr. 68601
91662	Elco Corp. Willow Grove, Pa.
93656	Electric Cord Co. 1275 Bloomfield Avenue Caldwell, N.J.
94310	Tru-Ohm Products Memcor Components Div. P.O. Box 890 Huntington, Ind. 46750
94696	Magnecraft Electric Co. 5579 North Lynch Chicago, Ill.
95348	Gordos Corp. 250 Glenwood Ave. Bloomfield, N.J. 07003
95712	Dage Electric Co., Inc. Hurricane Road Franklin, Indiana

TABLE 6-4.
Schematics and Component Layouts

Circuit	Schematic or Component Layout	Page No.
Power Supply	21782D	66
Power Supply	PC-161	67
Lamp Driver	21783D	68
Lamp Driver	PC-162	69
Output Converter	21784E	71
Output Converter	PC-163	70
Misc. Gates	21785E	72
Misc. Gates	PC-165	73
Bidirectional Counter	21786E	75
Bidirectional Counter	PC-166	74
Level Sensors	21787E	76
Level Sensors	PC-167	77
Integrator	21788D	78
Integrator	PC-168	79
Main Chassis	21789E	81
Model 4192 Output Converter	21792E	83
Model 4190 Input Head	21790E	85
Model 4190 Input Head	PC-174, PC-175	84
BCD Converter	21791D	87
BCD Converter	PC-173	86



NOTES:

1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED.
2. ⊘ INTERNAL SCREWDRIVER ADJ.
3. K 1000 OHM
4. pf PICOFARAD
5. ↻ CLOCKWISE ROTATION
6. ALL PIN CONNECTIONS ARE FROM PC-161

HIGHEST REFERENCE DESIGNATION			
R126	C108	Q110	D108
J103			

REFERENCE DESIGNATION NOT USED			

PRELIMINARY
FOR ENGINEERING USE

REVISIONS			
LTR	ECO NO.	APPR	DATE
A			

MODEL	NEXT ASSEMBLY	QUAN
4.9		1

USED ON

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED: FRAC ± 1/64, DEC ± .005, ANG ± 1°. DO NOT SCALE.

DRN WP DATE 8-21-67
CKD VG DATE 11-10-67
ENG. APPR. DATE
PILOT RELEASE DATE
PROD RELEASE DATE

KEITHLEY INSTRUMENTS CLEVELAND, OHIO

MATERIAL
FINISH

TITLE SCHEMATIC POWER SUPPLY

PART NUMBER 21782D

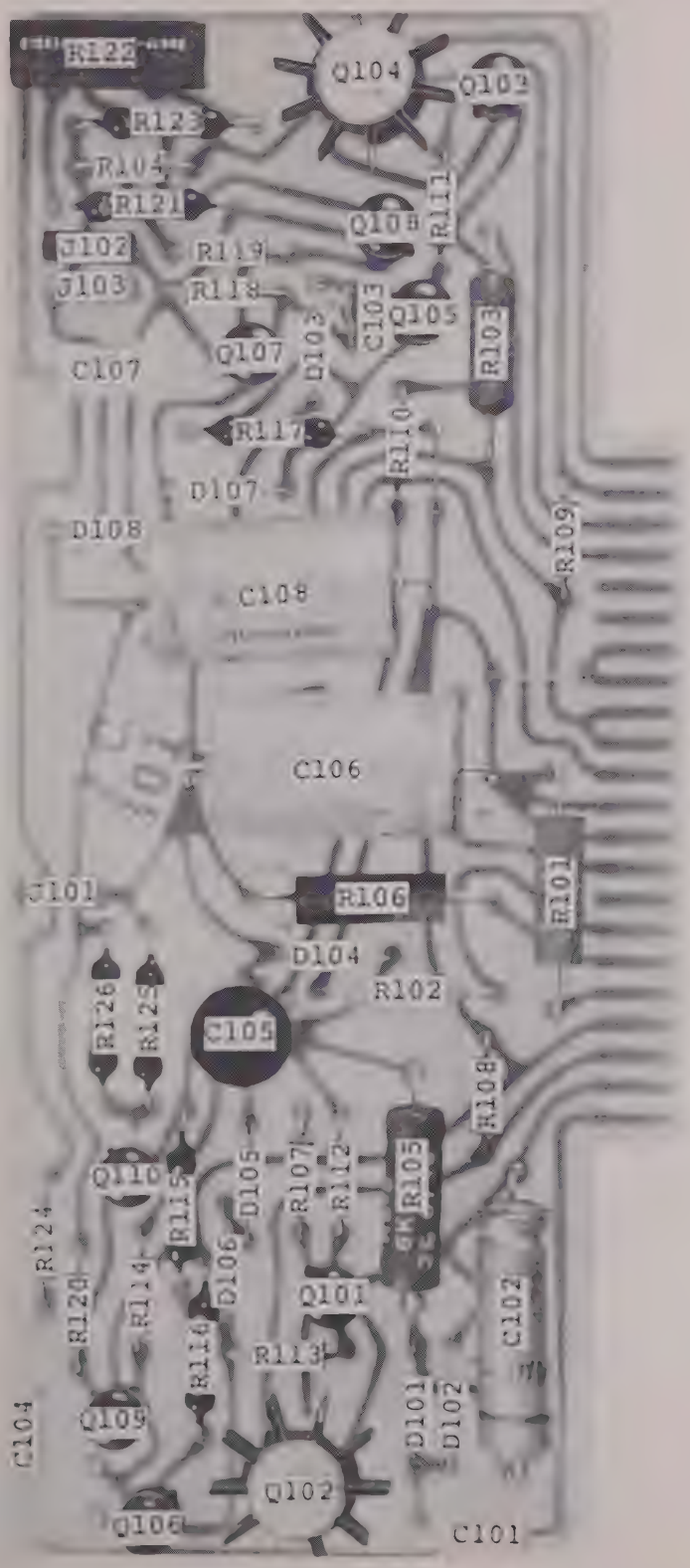
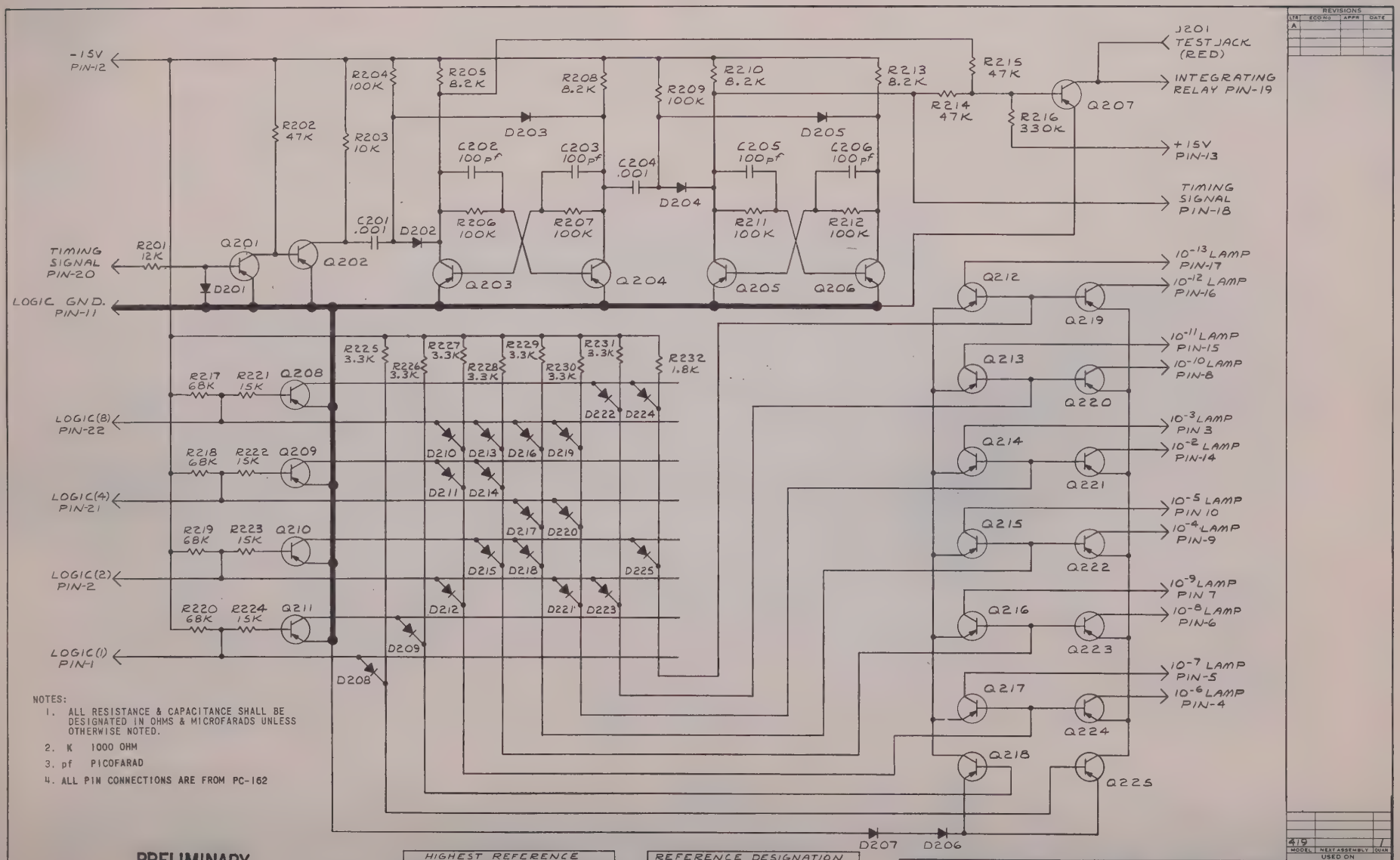


FIGURE 34. Component Layout, PC-161.



NOTES:

1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED.
2. K 1000 OHM
3. pf PICOFARAD
4. ALL PIN CONNECTIONS ARE FROM PC-162

PRELIMINARY
FOR ENGINEERING USE

HIGHEST REFERENCE DESIGNATION			
R232	D225	Q225	C206
J201			

REFERENCE DESIGNATION NOT USED			

REVISIONS			
LTR	ECO NO	APPR	DATE
A			

USED ON			
MODEL	NEXT ASSEMBLY	QUAN	
419		1	

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED: FRAC ± 1/64, DEC ± .005, ANG ± 1°
DO NOT SCALE

DRN WP DATE 8-21-67
CKD DATE 10-4-67
ENG/APPR DATE
PILOT RELEASE DATE
PROD. RELEASE DATE

KEITHLEY INSTRUMENTS CLEVELAND OHIO

TITLE SCHEMATIC LAMP DRIVER

MATERIAL
FINISH

PART NUMBER 21783D

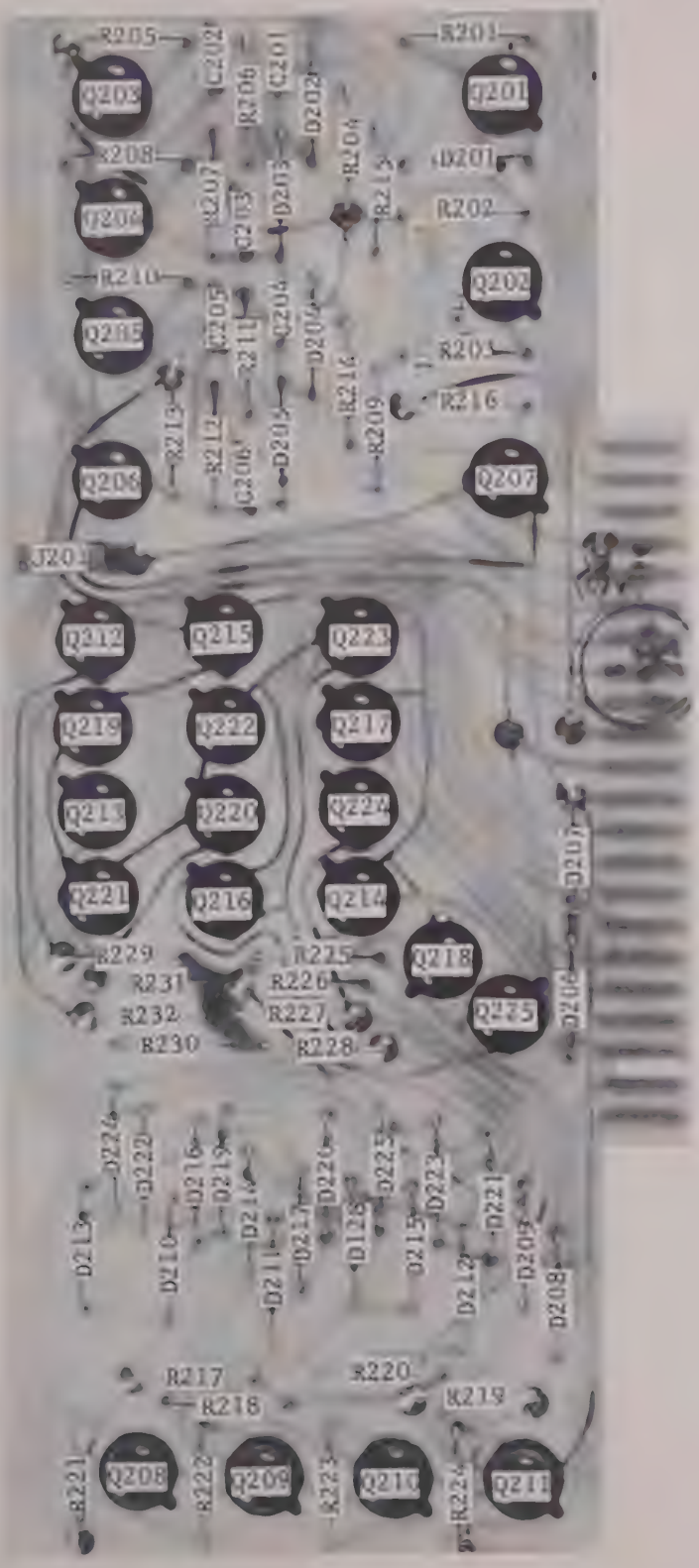


FIGURE 35. Component Layout, PC-162

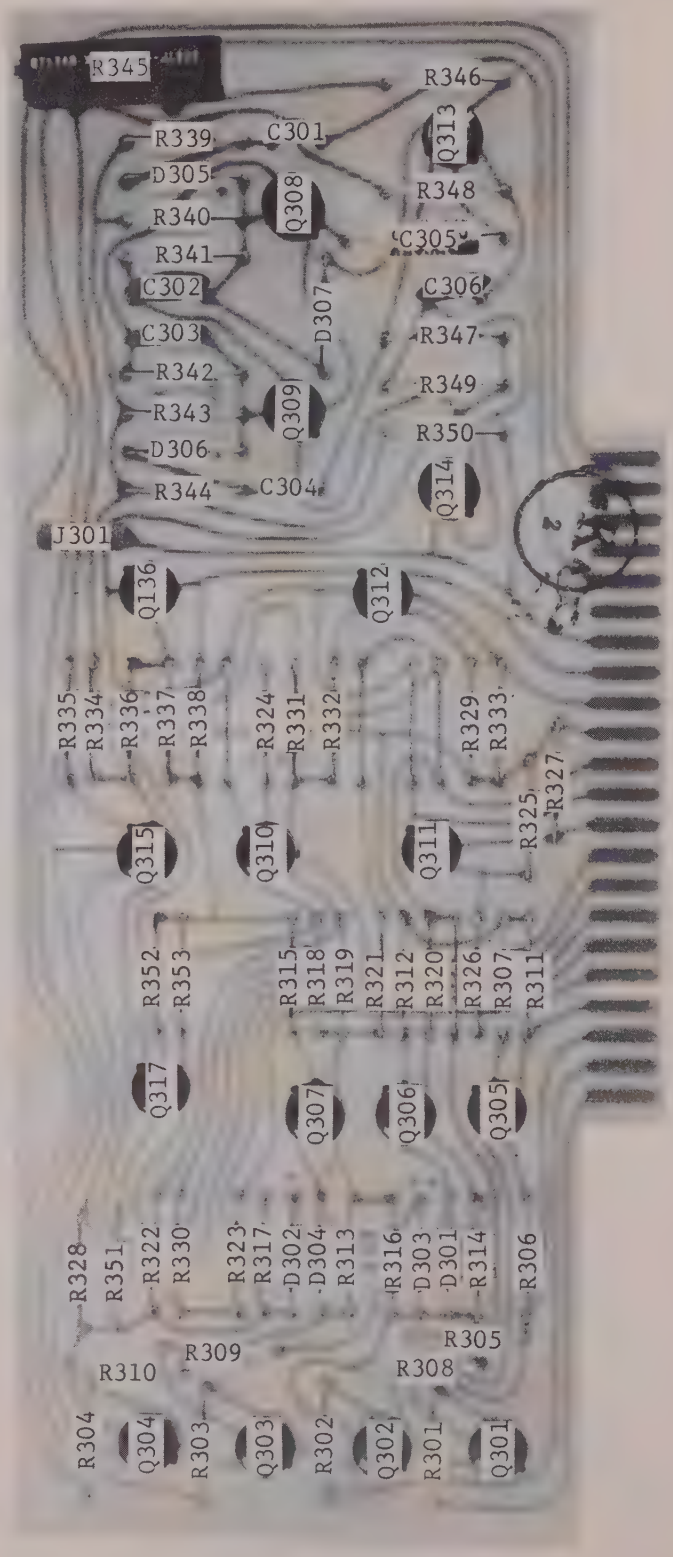
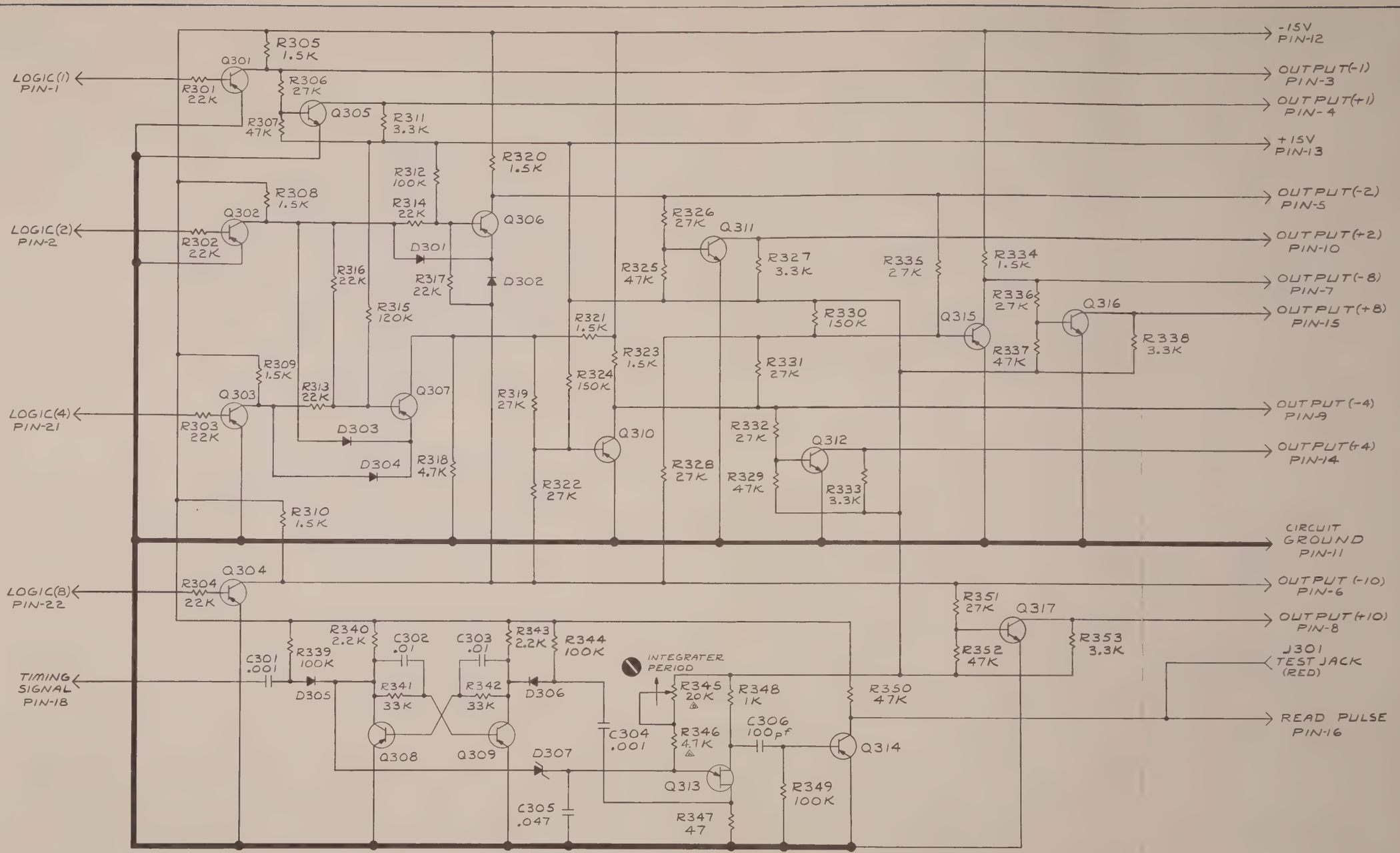


FIGURE 36. Component Layout, PC-163



NOTES:

1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED.
2. ⊘ INTERNAL SCREWDRIVER ADJ.
3. K 1000 OHM
4. pf PICOFARAD
5. ↑ CLOCKWISE ROTATION
6. ALL PIN CONNECTIONS ARE FROM PC-163

PRELIMINARY
FOR ENGINEERING USE

HIGHEST REFERENCE DESIGNATION			
R353	C306	D307	Q317
J301			

REFERENCE DESIGNATION NOT USED			

REVISIONS			
LTR	ECO NO	APPR	DATE
A	ECM 778	JAL	1-17-68
B	ECM 779	JAE	1-17-68

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED			
FRAC	DEC	ANG	
± 1/64	± .005	± 1°	
DO NOT SCALE			

DRN WP DATE 8-31-67
CKD JG DATE 11-8-67
ENG APPR DATE
PILOT RELEASE DATE
PROD RELEASE DATE

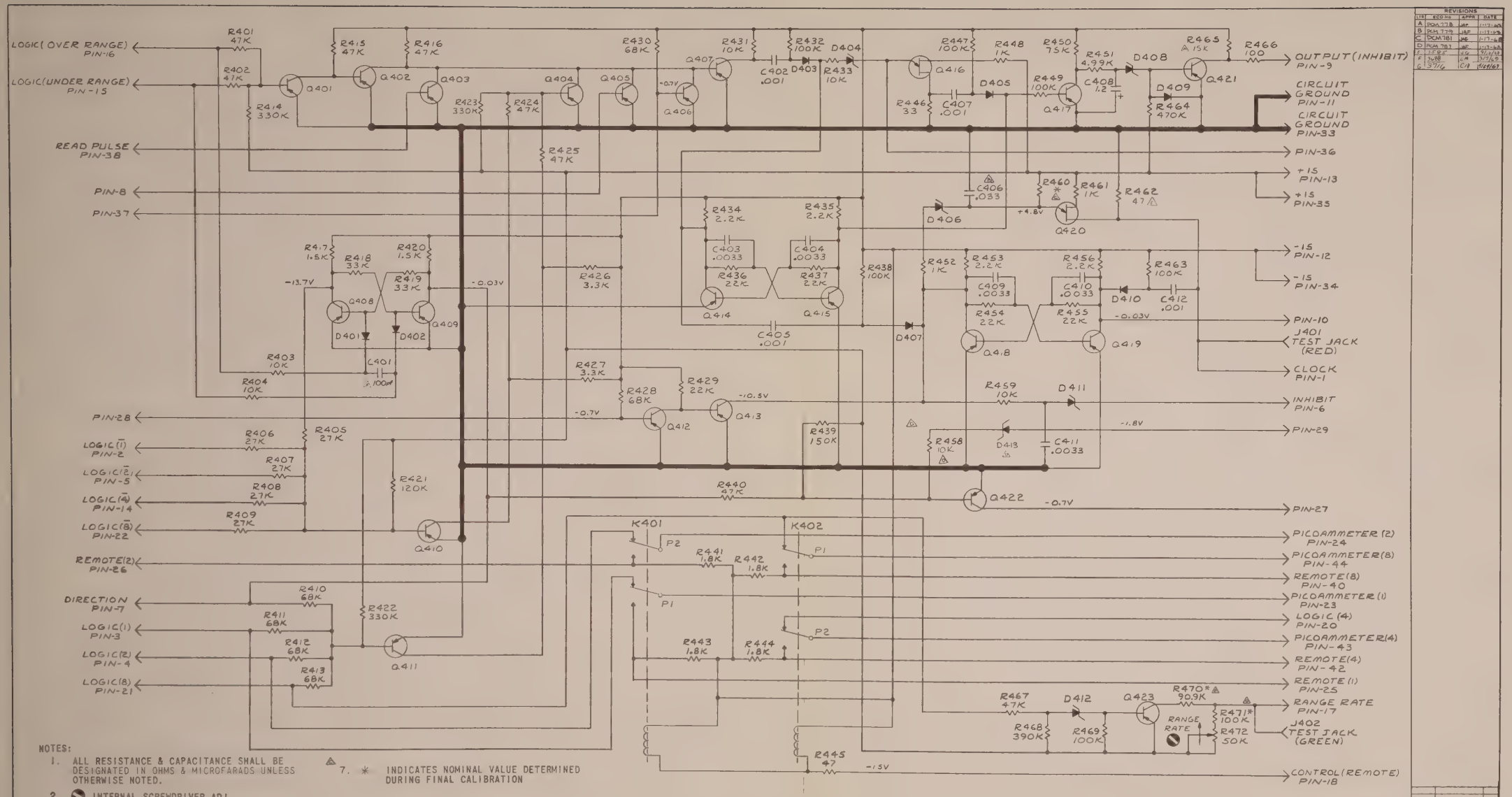
KEITHLEY INSTRUMENTS CLEVELAND, OHIO

MATERIAL
FINISH

TITLE SCHEMATIC OUTPUT CONVERTER

PART NUMBER 21784E

419 MODEL | NEXT ASSEMBLY | QUAN USED ON



NOTES:

1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED.
2. ⊘ INTERNAL SCREWDRIVER ADJ.
3. K 1000 OHM
4. pf PICOFARAD
5. ↑ CLOCKWISE ROTATION
6. ALL PIN CONNECTIONS ARE FROM PC-165
7. ✳ INDICATES NOMINAL VALUE DETERMINED DURING FINAL CALIBRATION

PRELIMINARY
FOR ENGINEERING USE

HIGHEST REFERENCE DESIGNATION			
R472	C412	D413	Q423
J402	K402		

REFERENCE DESIGNATION NOT USED			
R457 △			

REVISIONS			
LTR	ECO NO	APPR	DATE
A	PCM 778	JAP	1-13-65
B	PCM 779	JBF	1-13-65
C	PCM 781	JAP	1-13-65
D	PCM 783	JBF	1-13-65
E	1585	JG	9/15/66
F	3488	GM	3/7/67
G	3776	CH	11/4/67

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED		
FRAC	DEC	ANG
± 1/64	± .005	± 1°
DO NOT SCALE		

DRN WP DATE 10-9-67
CHD DATE
ENG APPR DATE
PILOT RELEASE DATE
PROD RELEASE DATE

KEITHLEY INSTRUMENTS CLEVELAND OHIO

MATERIAL
FINISH

TITLE SCHEMATIC MISC. GATES

PART NUMBER 21785E

419

MODEL NEXT ASSEMBLY USED ON

FIGURE 37. Component Layout, PC-165

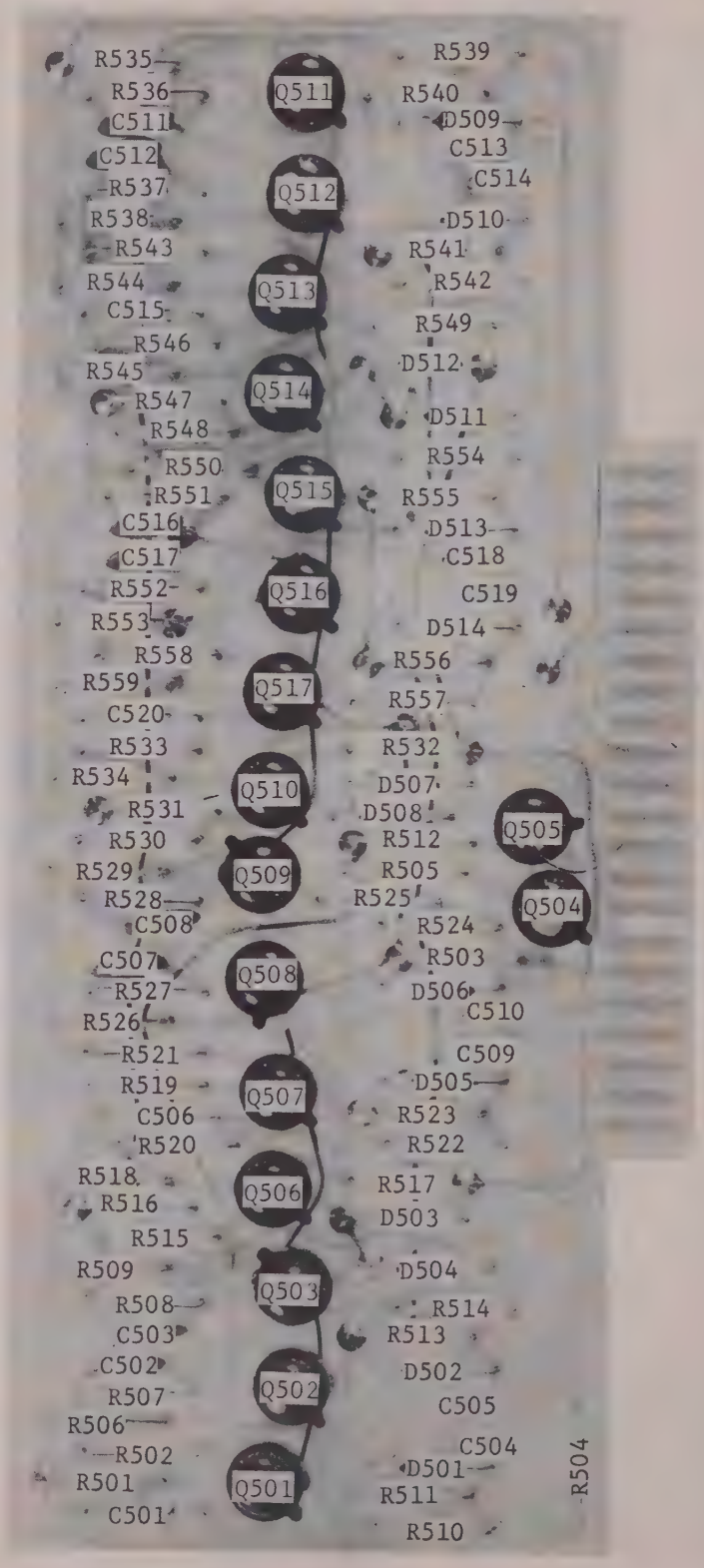
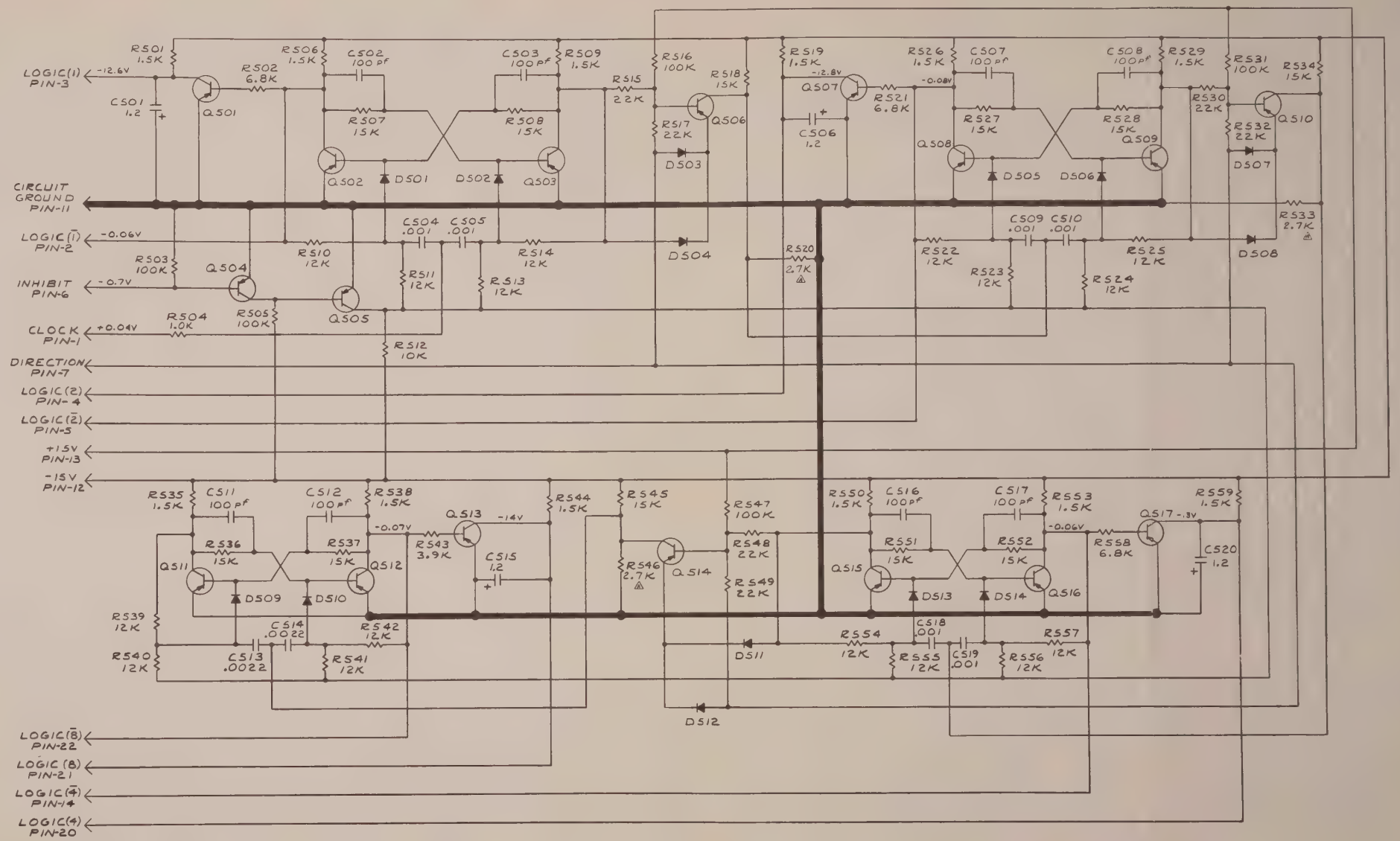


FIGURE 38. Component Layout, PC-166



NOTES:

1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED.
2. K 1000 OHM
3. pf PICOFARAD
4. ALL PIN CONNECTIONS ARE FROM PC-166

HIGHEST REFERENCE DESIGNATION			
R559	C520	D514	Q517

REFERENCE DESIGNATION NOT USED			

REVISIONS			
LTR	ECO NO.	APPR	DATE
A	3711	LG	9-24-68

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED		
FRAC	DEC	ANG
± 1/64	± .008	± 1°

DO NOT SCALE

DRWN WP DATE 10-13-67
ENG DATE
PRG /PPR DWH DATE 6-5-68
PILOT RELEASE DATE
PROD RELEASE DATE

KEITHLEY INSTRUMENTS CLEVELAND OHIO

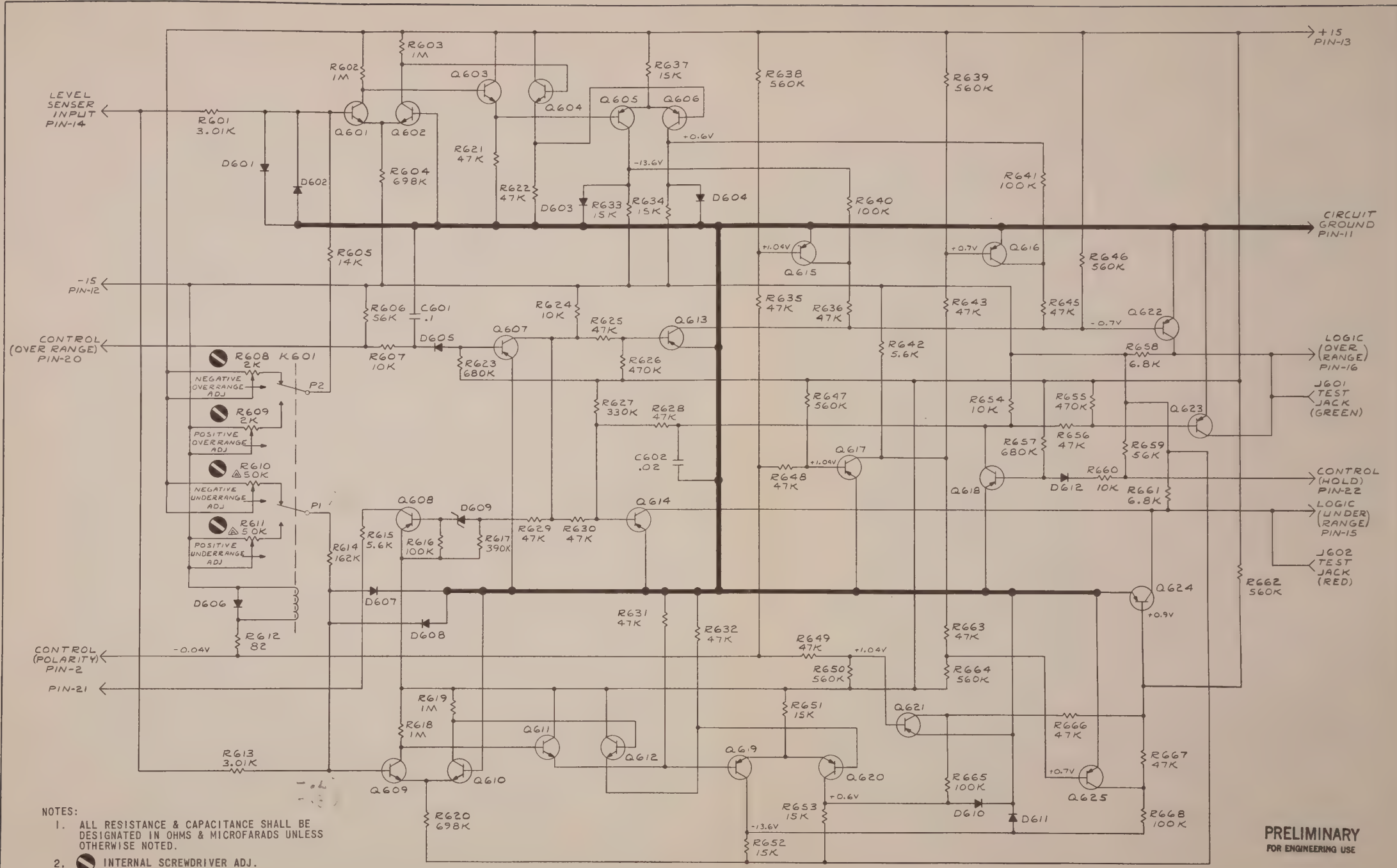
MATERIAL

FINISH

TITLE SCHEMATIC BIDIRECTIONAL COUNTER

PART NUMBER 21786E

419 MODEL NEXT ASSEMBLY USED ON



NOTES:

1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED.
2. INTERNAL SCREWDRIVER ADJ.
3. M MEGOHM
4. K 1000 OHM
5. CLOCKWISE ROTATION
6. ALL PIN CONNECTIONS ARE FROM PC-167

HIGHEST REFERENCE DESIGNATION			
R668	C602	Q625	D612
J602	K601		

REFERENCE DESIGNATION NOT USED			
R644			

PRELIMINARY
FOR ENGINEERING USE

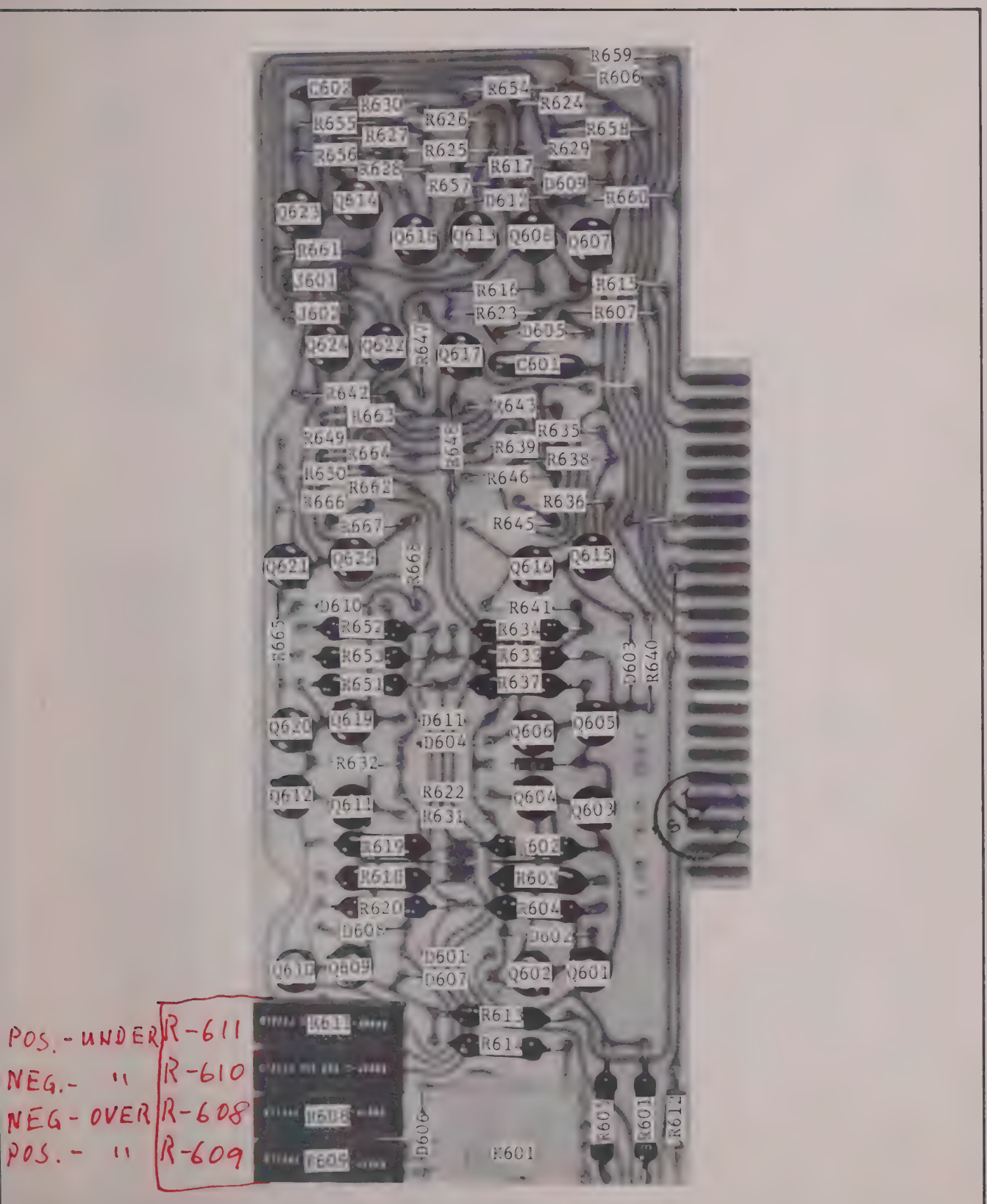
DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED: FRAC ±1/64, DEC ±.005, ANG ±1°. DO NOT SCALE.
DRN WP DATE 10-24-67
CHD DATE
ENG APPR DATE
PILOT RELEASE DATE
PROD RELEASE DATE
WATER AL
FINISH

KEITHLEY INSTRUMENTS CLEVELAND, OHIO

TITLE SCHEMATIC LEVEL SENSERS

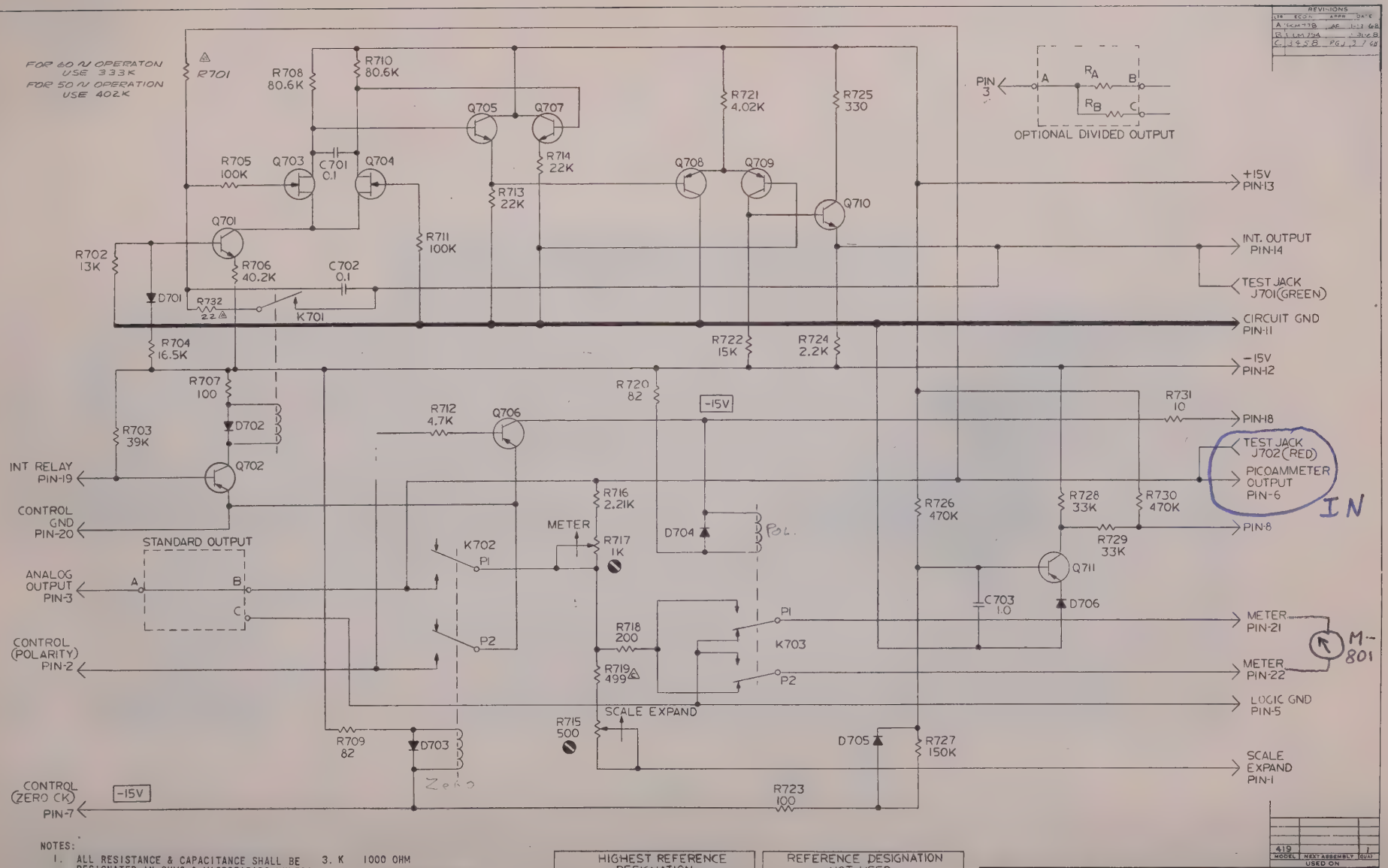
PART NUMBER 21787E

419 MODEL NEXT ASSEMBLY USED ON



POS. - UNDER R-611
NEG. - " R-610
NEG - OVER R-608
POS. - " R-609

FIGURE 39. Component Layout, PC-167



REVISIONS

LTR	ECO#	APPD	DATE
A	LCM-778	AF	1-17-68
B	LCM-794		3-12-68
C	LCM-858	RGJ	7-1-68

NOTES:

1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED.
2. ⊘ INTERNAL SCREWDRIVER ADJ.
3. K 1000 OHM
4. ↑ CLOCKWISE ROTATION
5. ALL PIN CONNECTIONS ARE FROM PC-168

HIGHEST REFERENCE DESIGNATION			
Q711	R732	D706	K703
J702		C703	

REFERENCE DESIGNATION NOT USED			

DRN RGJ	DATE 6-14-67	KEITHLEY INSTRUMENTS CLEVELAND OHIO
CKD	DATE	
ENG	DATE	
APPR JWN	DATE 6-5-68	
PILOT RELEASE	DATE	
PROD RELEASE	DATE	

MATERIAL

FINISH

TITLE SCHEMATIC — INTEGRATER

PART NUMBER 21788D

419 MODEL | NEXT ASSEMBLY | USED ON | QUAN

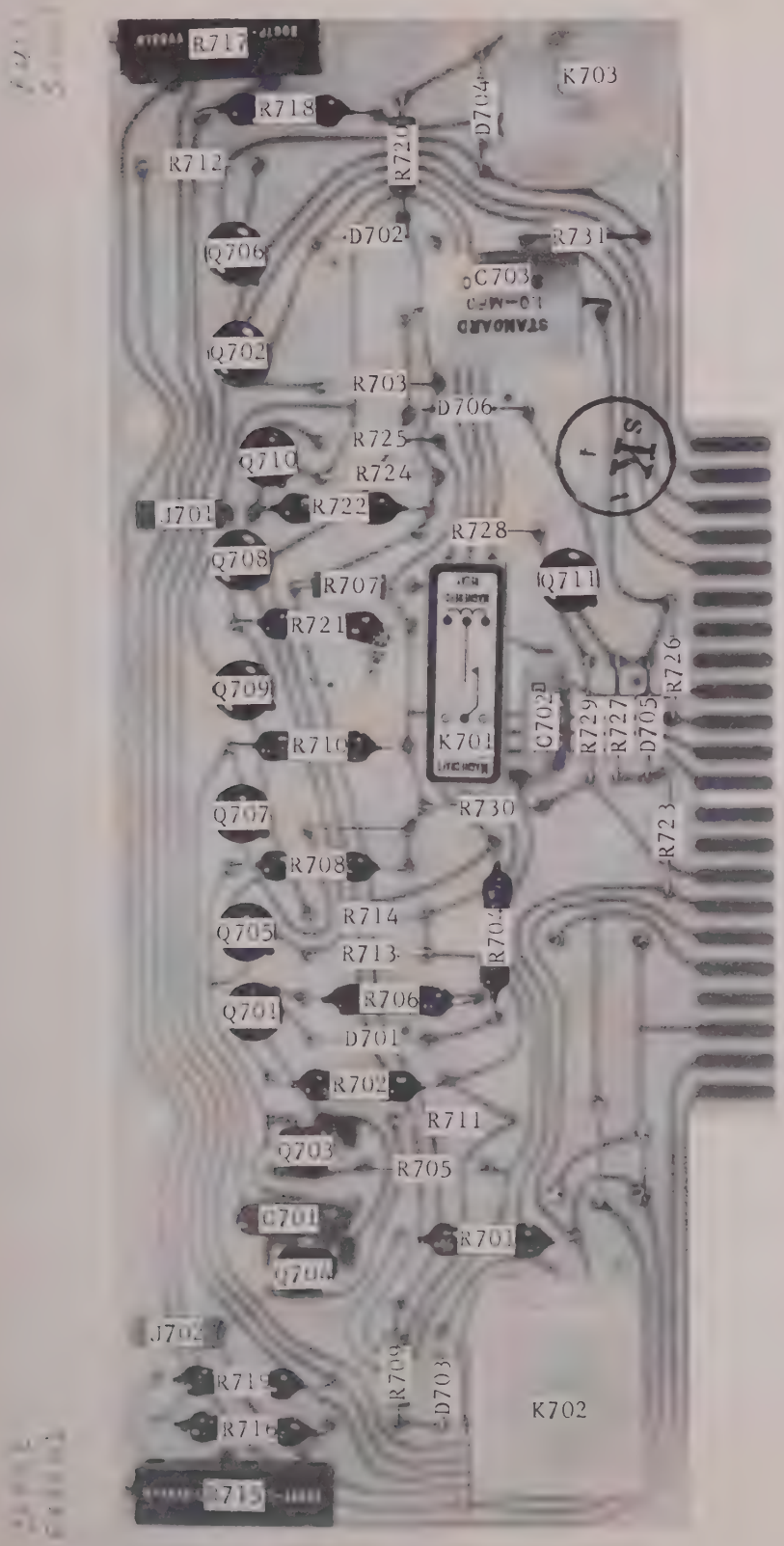
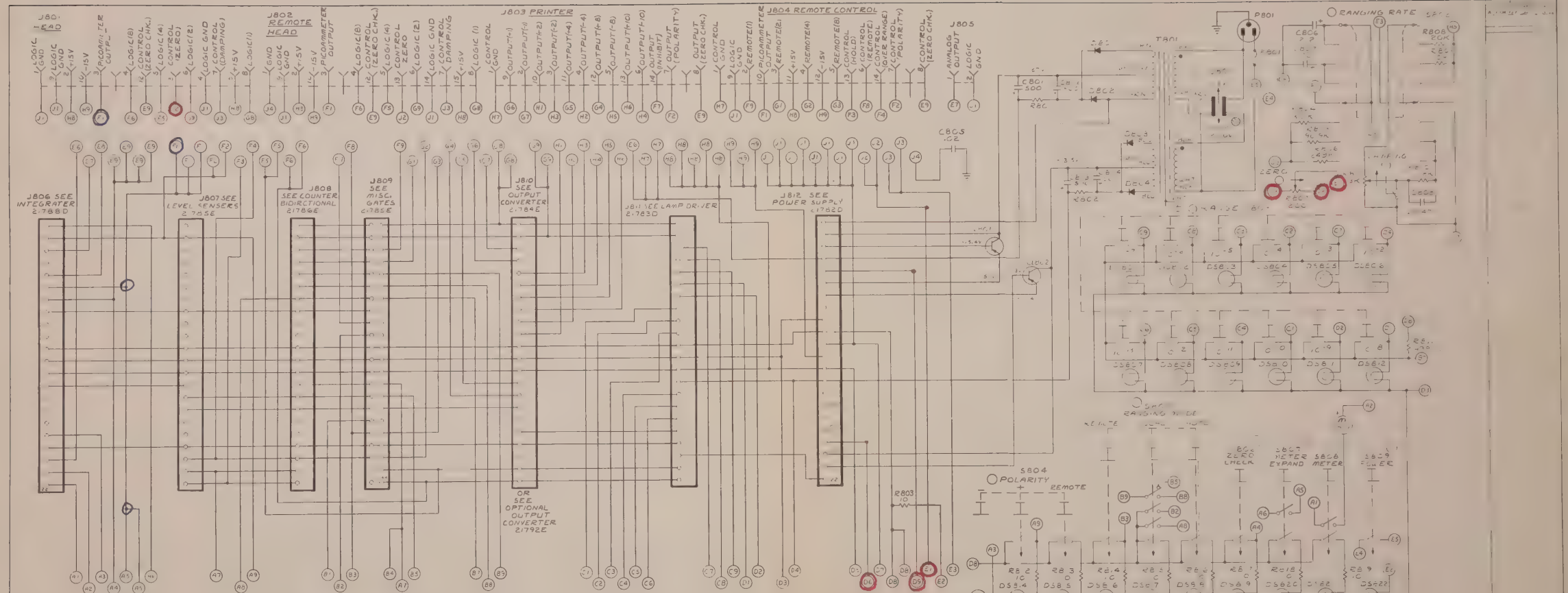


FIGURE 40. Component Layout, PC-168



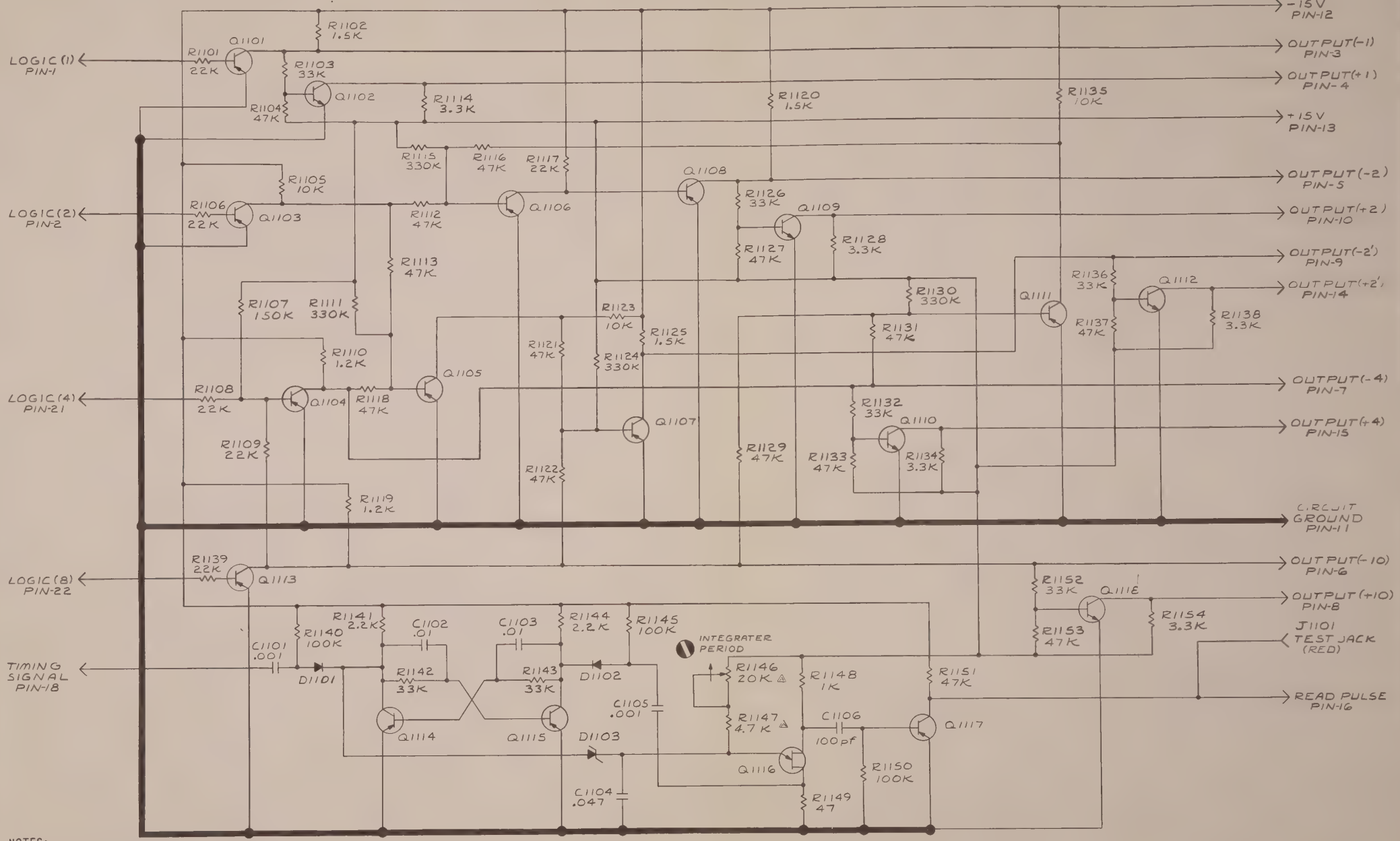
NOTES:

1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED.
2. ○ FRONT PANEL CONTROL
3. ⊘ REAR PANEL CONTROL
4. K 1000 OHM
5. ↻ CLOCKWISE ROTATION
6. ALL VOLTAGE MEASUREMENTS ARE MADE WITH RESPECT TO POWER SUPPLY GND. WITH A 200 MEG VTVM WITH LINE 117 V AC. READINGS MAY VARY ± 15%.

CONTROLS ARE SET AT THE FOLLOWING; 10^{-2} AMPERE RANGE, LOCAL RANGING, RANGE RATE IN POSITION #1, +POLARITY, METER ON, MIN. DAMPING, INPUT CAPPED AND INSTRUMENT PROPERLY ZEROED.

HIGHEST REFERENCE DESIGNATION				
R820	C808	DSC4	Q802	
P80	*801	T801	S809	
DS822	J812			

REFERENCE DESIGNATION NOT USED



NOTES:

1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED.
2. ⏀ INTERNAL SCREWDRIVER ADJ.
3. K 1000 OHM
4. pf PICOFARAD
5. ↑ CLOCKWISE ROTATION
6. ALL PIN CONNECTIONS ARE FROM PC-164

HIGHEST REFERENCE DESIGNATION			
R1154	C1106	Q1118	J1101
D1103			

REFERENCE DESIGNATION NOT USED			

PRELIMINARY
FOR ENGINEERING USE

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED			DRN WP	DATE 9-22-67
FRAC	DEC	ANG	CKD	DATE 10-13-67
± 1/64	± .005	± 1°	ENG APPR	DATE
			PROD RELEASE	DATE
DO NOT SCALE			PROD RELEASE	DATE

KEITHLEY INSTRUMENTS CLEVELAND OHIO

MATERIAL

F.N. SH

TITLE SCHEMATIC OPTIONAL OUTPUT CONVERTER

PART NUMBER 21792E

4192 MODEL NEXT ASSEMBLY QUAN USED ON

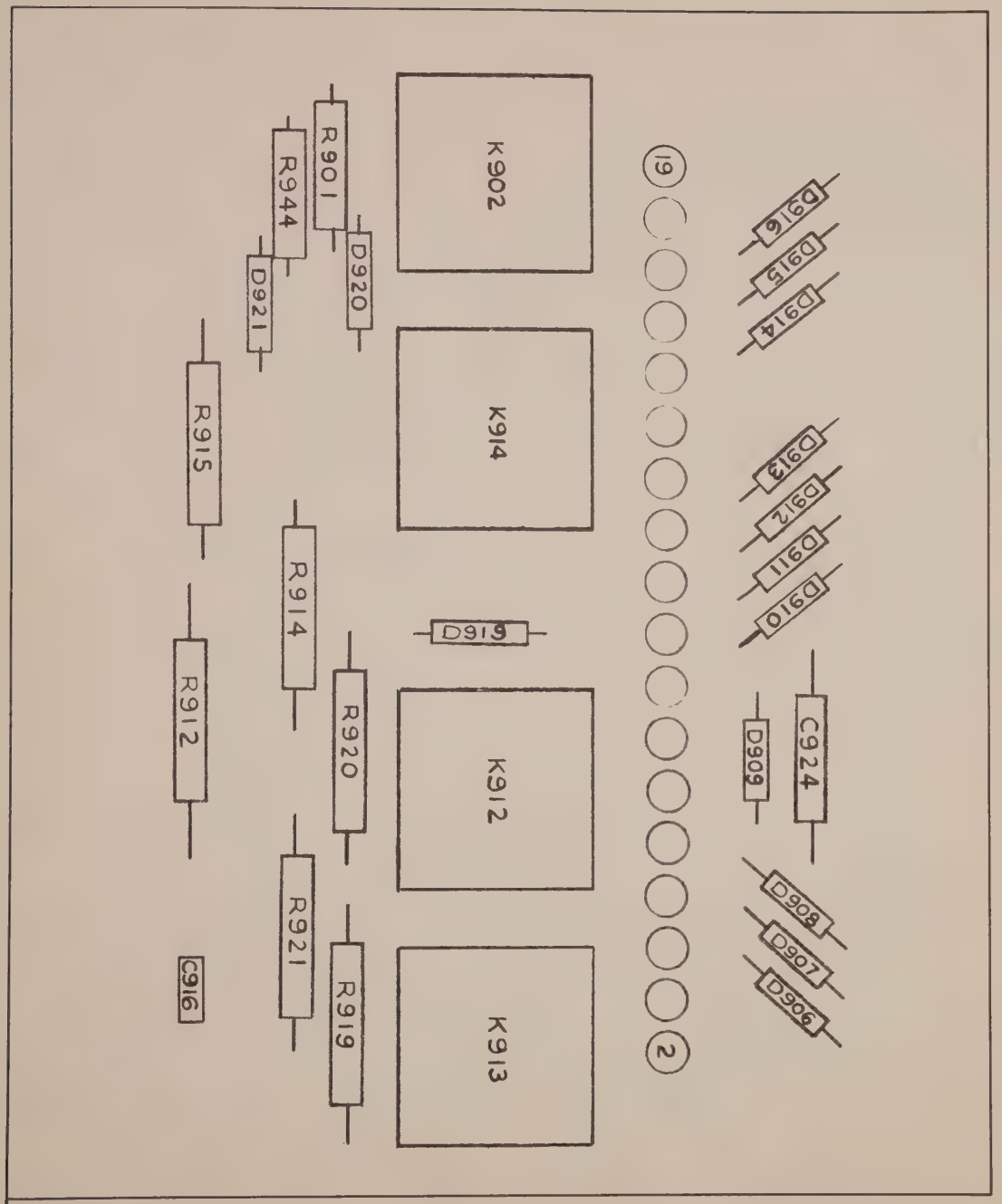


FIGURE 41a. Component Layout, PC-174

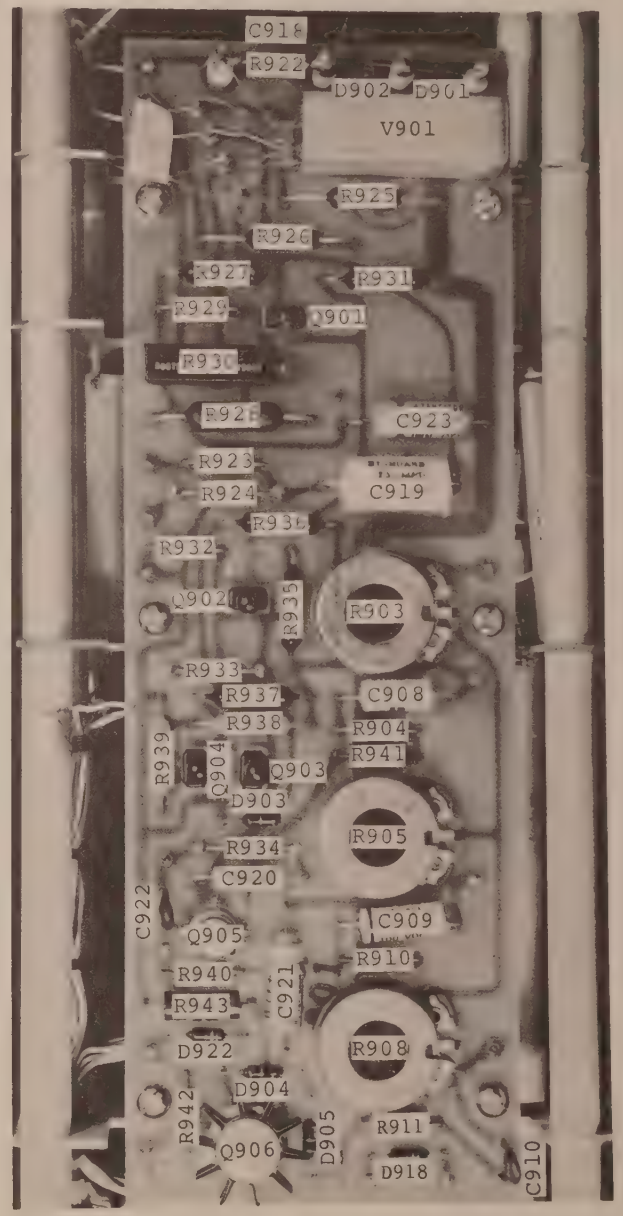
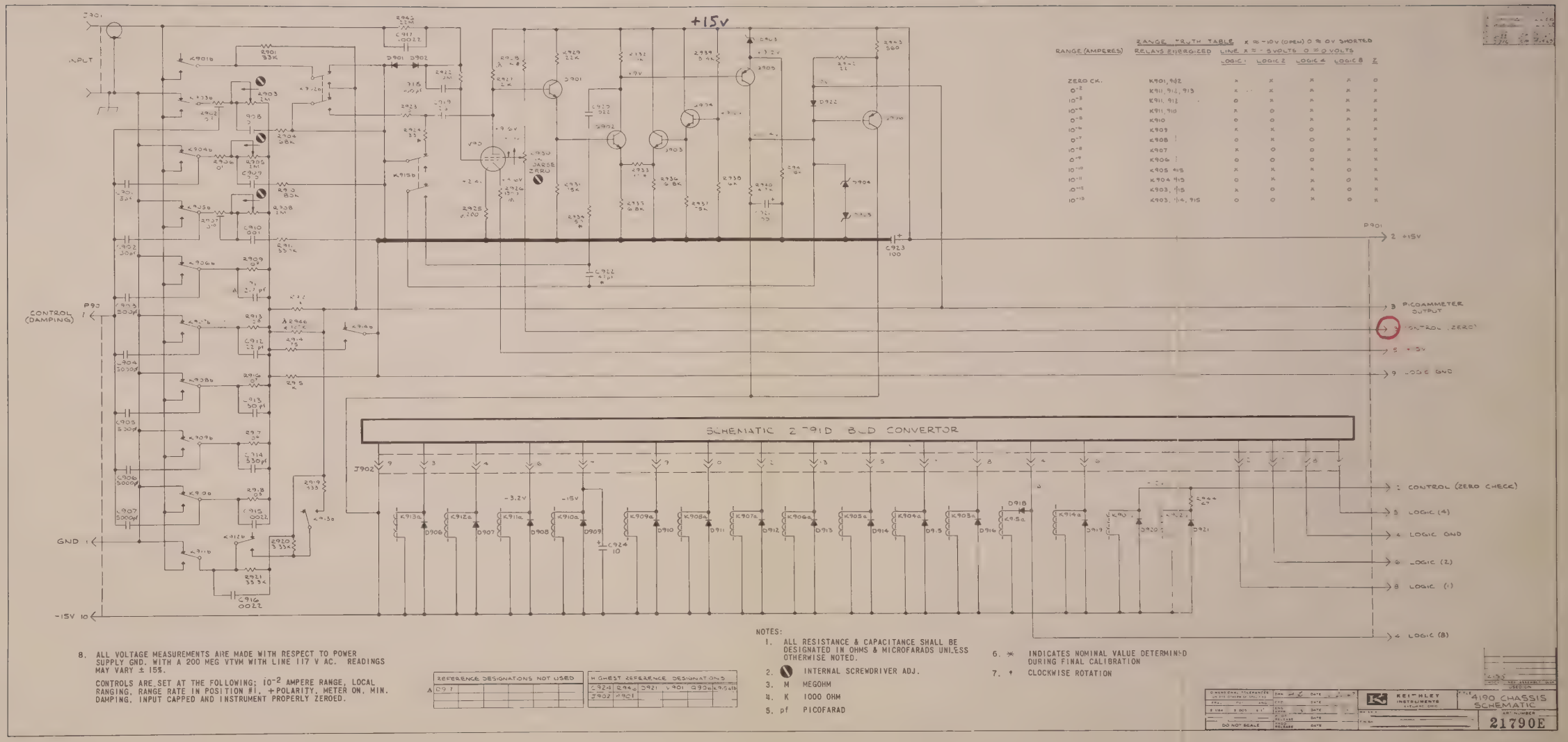


FIGURE 41b. Component Layout, PC-175



8. ALL VOLTAGE MEASUREMENTS ARE MADE WITH RESPECT TO POWER SUPPLY GND. WITH A 200 MEG VTVM WITH LINE 117 V AC. READINGS MAY VARY ± 15%.

CONTROLS ARE SET AT THE FOLLOWING: 10^{-2} AMPERE RANGE, LOCAL RANGING, RANGE RATE IN POSITION #1, +POLARITY, METER ON, MIN. DAMPING, INPUT CAPPED AND INSTRUMENT PROPERLY ZEROED.

REFERENCE DESIGNATIONS NOT USED					
A	D917				

HIGHEST REFERENCE DESIGNATIONS					
C924	R946	D921	K901	Q902	K905 alt
J902	P901				

NOTES:

1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED.
2. INTERNAL SCREWDRIVER ADJ.
3. M MEGOHM
4. K 1000 OHM
5. pf PICOFARAD
6. * INDICATES NOMINAL VALUE DETERMINED DURING FINAL CALIBRATION
7. † CLOCKWISE ROTATION

DO NOT SCALE

KEITHLEY INSTRUMENTS

TITLE 4190 CHASSIS SCHEMATIC

ART-NUMBER 21790E

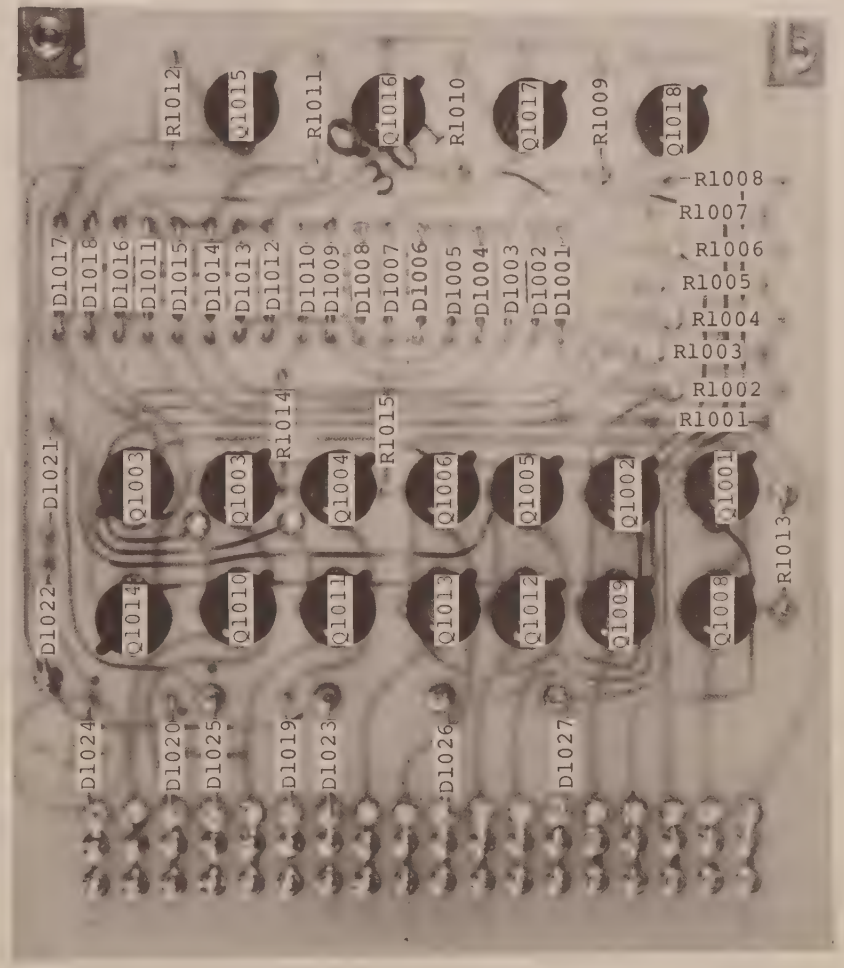
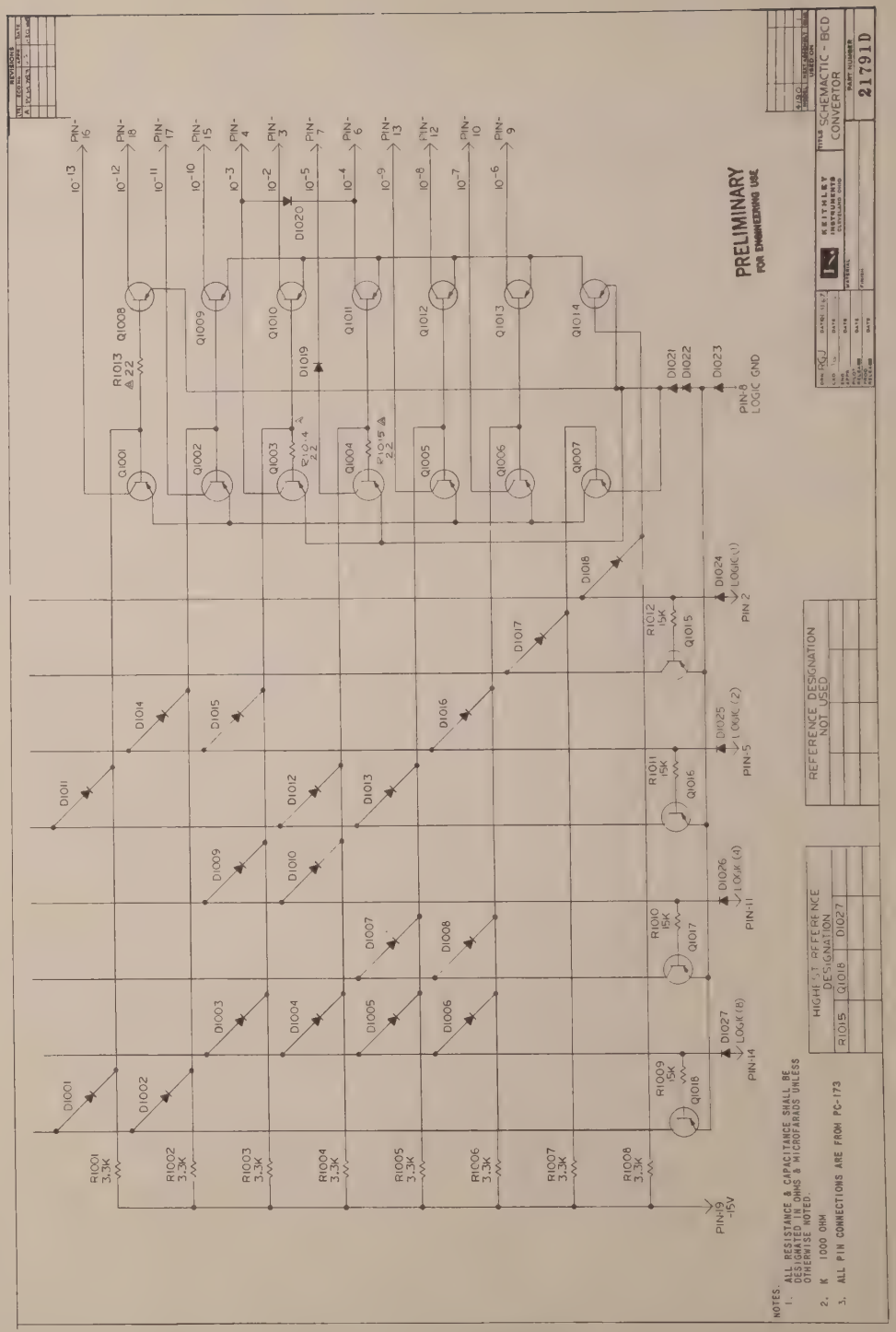


FIGURE 42. Component Layout, PC-173



KEITHLEY INSTRUMENTS, INC.
REPAIR & CALIBRATION FORM

DEL NO. _____
RIAL NO. _____

DATE _____

R-

IP INSTRUMENT & FORM TO:

LES SERVICE DEPT.
ITHLEY INSTRUMENTS, INC.
3775 AURORA ROAD
LEVELAND, OHIO 44139

FROM:

USER'S NAME _____
RETURN ADDRESS _____
_____
CITY _____
STATE _____ ZIP _____
TELEPHONE _____

REASON FOR RETURN. Check appropriate box.
☐ Repair and Recalibration
☐ Recalibration only. (If repairs are required to meet specifications, an additional repair charge will be added to recalibration cost.)

CALIBRATION REPORT. Specify report desired. (See reverse side of form for details.)
☐ Calibration Report (Certified Traceable to N.B.S.)
☐ Calibration Report (Production Calibration Equipment at the factory)
☐ Certificate of Compliance

DESCRIPTION OF PROBLEM. (Include a block diagram of instruments connected in system. Recorder charts or other data would be helpful.)

_____
_____
_____
_____

Is problem constant or intermittent? _____

OPERATING CONDITIONS.
Control setting (range, multiplier, etc.) _____
Line voltage used _____ Line frequency used _____
Temperature _____ °F Temperature variation ± _____ °F
Humidity (high, medium, low) _____
Other (please specify, such as line transients, etc.) _____

EQUIPMENT USED.
Signal source _____ Source impedance _____
Readout device _____ (Recorder, oscilloscope, etc.)
Cables used _____ Length _____

ADDITIONAL INFORMATION. Please indicate any other pertinent information which may help the Keithley Repair and Calibration Department. (If repairs or modifications have been made to instrument by other than Keithley personnel, please specify below.)

_____
_____
_____

REV 0172

CALIBRATIONS AVAILABLE AT KEITHLEY INSTRUMENTS. EFFECTIVE: FEBRUARY 1, 1972

Listed and defined below are the four types of calibrations and their associated report formats which are presently available at Keithley Instruments. They fall into the following categories:

1. Report of Calibration Certified Traceable to the National Bureau of Standards
2. Calibration Report
3. Certificate of Compliance
4. Recalibration

All calibration and certification performed by Keithley Instruments is in accord with MIL-C-45662A.

Prices shown below are in addition to repair charges for any work necessary to place a customer's unit into first class condition prior to the calibration.

1. Report of Calibration Certified Traceable to the National Bureau of Standards.
This is a completely documented report, including all basic errors or deviations from nominal settings on appropriate ranges, terminals, dials, etc. Work is performed using the primary standards of the company with secondary transfers kept to a minimum. The NBS test numbers for the latest recalibration of the primary standards are furnished.

By definition, the above is performed in our Standards Laboratory so that random operator induced error is minimized and maximum protection to the equipment used is maintained.

This type of calibration is not recommended for instruments with a basic inaccuracy of 1% or greater. The precision involved in this report makes it uneconomical for such instruments. The Calibration Report listed below (No. 2) would be better suited in this case.

The Report of Calibration Certified Traceable to the National Bureau of Standards is available on the following instruments at the prices listed:

Model 140	$275	Model 5155-10^{8}	$ 50
Model 260	$225	Model 5155-10^{9}	$ 50
Model 261	$375	Model 5155-10^{10}	$ 50
Model 662	$275	Model 5155-10^{11}	$ 60
Model 5155 (Complete Set)	$295	Model 5155-10^{12}	$ 60
		Model 5155-10^{13}	$ 80

2. Calibration Report.
This report shows only the cardinal range, terminal, dial, etc. errors as determined by production calibration equipment and personnel. The production equipment is maintained traceable by transfer techniques against the primary standards maintained by the company. We attest to this fact and list basic deviations from nominal but the conditions of calibration are not as precisely controlled as the previous report nor are NBS test numbers supplied.

This report is available for any instrument in our line. The following price has been established for this report:

Model 261 . . . . . $ 60
Prices for other units can be estimated upon request.

3. Certificate of Compliance.
This is merely a restatement of the basic guarantee that the instrument was calibrated on equipment that is maintained by our standards personnel against primary standards. No report is issued.

This Certificate of Compliance is available at no charge for any instrument with the exception of the Model 261.

A newly purchased Model 261 or one returned for repair or recalibration is automatically supplied with a Calibration Report (as described in (2) above). The nature of this instrument makes it necessary to complete this report to ascertain specified accuracy. This Calibration Report is forwarded to the customer with the instrument. The $60 charge is incorporated as part of the normal calibration charge of the Model 261.

4. Recalibration.
This is a recalibration of the instrument according to our factory calibration procedures.

Model 260 . . . . . $ 90 (No report supplied. A Certificate of Compliance can be had at no charge if requested).

Model 261 . . . . . $ 60 (Calibration Report as described in (2) above is supplied. See (3) for explanation).

All other instruments are on a time and material basis for the particular unit involved.

All prices subject to change without prior notification.

KEITHLEY INSTRUMENTS, INC.

28775 AURORA ROAD • CLEVELAND, OHIO 44139 • (216) 248-0400
TELEX: 98-5469 • CABLE: KEITHLEY